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ADAPTIVE DUAL LAYER SLIDING MODE IMPEDANCE CONTROLLER FOR SPACE ROBOT ON-ORBIT AUXILIARY DOCKING OPERATION

Abstract

There are a large number of satellites in Earth orbit, but only a small part of them can work normally. In general, the main reason for satellite failure is that the fuel it carries is exhausted or a component is damaged. If fuel can be replenished or damaged components can be replaced, the cost of space exploration can be considerably reduced. Using space robots to perform the above tasks has excellent economic prospects, but it requires space robots to have the ability to complete the auxiliary docking operation. That is, the controller can achieve extremely control accuracy of position and output force of the post-capture satellite docking device. Based on this analysis, the dynamic modes of space robot open-loop system and satellite system before capture are established by using Lagrange function. Then, combined with Newton's third law, velocity constraints of capture points and closed-chain geometric constraints, the closed-chain dynamic model of hybrid system after capture is obtained, and the impact effect and impact force are calculated utilize the momentum conservation. In order to achieve high-precision control of output force, the impedance model is established based on the Jacobian relation between the satellite docking device relative to the space robot base coordinate system. Sliding mode control (SMC) is widely used in the trajectory control of space robots because of simple structure and strong robustness. However, the switching function of SMC will generate the chattering problem in "equivalent control". If SMC is applied to auxiliary docking operation, the trajectory control accuracy of the post-capture hybrid system will be decreased. Therefore, an adaptive double layer sliding mode control (ADLSMC) is proposed based on the impedance model. It improves the control accuracy of position by using double layer sliding mode function and the adaptive gain coefficient to decrease the chattering in the equivalent control stage. The stability of the hybrid system is proved by the Lyapunov theorem, and the effectiveness of ADLSMC are verified by numerical simulation. The results show that the position, attitude and output force control accuracy of the docking device can reach 0.002m, 0.01rad and 1N respectively.