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# OUTPUT FEEDBACK CONTROL BASED ON SLIDING MODE AND VIBRATION SUPPRESSION FOR A FLEXIBLE-BASE TWO-FLEXIBLE-LINK AND TWO-FLEXIBLE-JOINT SPACE ROBOT WITH ACTUATOR SATURATION

**Abstract**

With the development of space technology, more complex space tasks will be carried out in the future. Compared with astronauts, it is advantageous to use space robots. The space robot is mainly composed of a base, links and joints. The control accuracy of the space robot is affected by the vibration of the base, links and joints. The research on space robot motion control and vibration suppression is important. In this paper, the input-constrained output feedback method based on sliding mode and inhibiting flexible vibration scheme are developed for flexible base flexible link and flexible joint space robot with actuator saturation. Despite the fact that only base and joints position are available, the proposed controller obtains favorable performance. The elastic base and the flexible joints are regarded as linear spring and torsion springs. The flexible links are analyzed by the Eulerian Bernoulli model. Combined with Lagrange method the dynamic equations of space robot with flexible base two-flexible-link and two-flexible-joint is established. Based on the singular perturbation theory, the model is decomposed into a slow subsystem including the rigid variables and the link flexible vibration, and a fast subsystem including the base and joint flexible vibration. For the slow subsystem, the input-constrained output feedback method based on sliding mode is presented, which is composed of hyperbolic tangent function, saturation function, nonlinear filters and sliding mode control algorithm. A nonlinear filter is utilized in the controller development to remove the requirement of base and link velocity measurement. The saturation function is utilized to makes the controller bounded. However, in order to suppress the flexible vibration of the links of the slow subsystem, a hybrid trajectory reflecting the flexible vibration of the links and the rigid motion of the system is constructed by using the concept of virtual force, and an input-constrained output feedback hybrid method based on sliding mode controller is proposed to ensure the accurate tracking of the trajectory of the base and joint, while actively suppressing the flexible vibration of the links. For the fast subsystem, the linear quadratic optimal control algorithm is used to suppress the flexible vibration of the base and joints. The simulation results verify the control schemes effectiveness in trajectory tracking and flexible vibration suppression.