Paper ID: 69977
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IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Interactive Presentations - IAF MATERIALS AND STRUCTURES SYMPOSIUM (IP)

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FINITE TIME FAULT-TOLERANT CONTROL AND MULTIPLE VIBRATION SUPPRESSION OF SPACE ROBOT WITH ELASTIC BASE, ELASTIC JOINTS AND FLEXIBLE LINKS

Abstract

With the development of space science and technology, space robot has been endowed with extremely important position in the implementation of space tasks. It is expected to play a more important role and perform more complex on-orbit operation tasks. The manipulator of space robot system are mostly light and slender rods, in order to save costs and improve work efficiency, and the joints are often driven by flexible harmonics. However, space manipulators are usually installed on elastic guide rails, so the system is affected by multiple elasticity. In addition, the actuator of manipulators are prone to failure affected by external interference signals, faults or due to their own aging wear and other reasons. Therefore, the on-orbit operation of fully elastic space robots (elastic base, elastic joints and flexible links) with actuator failures is a great challenge. A finite time fault-tolerant control and multiple vibration suppression algorithm was proposed to solve the problem of fully elastic space robot with actuator failure and multiple flexible components. First of all, the dynamic models of the fully elastic space robot system is derived by multi-body theory. After that, based on singular perturbation theory, the model of a slow subsystem and a flexible fast subsystem are derived. In order to realize the precise control of the slow subsystem with faults, an extended state observer was proposed to realize the dynamic observation of actuator failure, and a sliding mode controller based on finite time was designed to realize active fault-tolerant control. At the same time, the vibration suppression of the flexible links are realized by combining the virtual force. The linear quadratic optimal control is proposed to suppress the vibration of elastic joints and elastic base. The simulation results show that the proposed control scheme can realize the accurate tracking of rigid motion and active suppression of multiple flexible vibrations under actuator faults, and has the advantage that the trajectory of the system can converge in finite time only by adjusting control parameters.