Robust H_∞ Control and Double Flexible Vibration Active Suppression of Space Robot with Flexible-Link and Flexible-Joint

*Liang Jie(1. Institute of Mechanical Engineering and Automation, Fuzhou University; 2. China Aerodynamics Research and Development Center; 3. School of Astronautics＆Aeronautic , University of Electronic Science and Technology of China), Li Chen(Institute of Mechanical Engineering and Automation, Fuzhou University)

Contact Author :	Liang Jie
Affiliation :	Institute of Mechanical Engineering and Automation, Fuzhou University
Address :	Institute of Mechanical Engineering and Automation, Fuzhou University, 2 Xueyuan Road, University Town, Fuzhou, Fujian, 350108
Email :	myamoy81@163.com
Phone :	+8615960207603
Fax(optional) :	
Presentation Preference(oral or poster) :	Oral

Keywords(no more than 5) :	space robot with flexible-link and flexible-joint, virtual desired trajectory, robust H_∞ control，double flexible vibration active suppression

Extended Abstract

Space robot system will play more and more important function in future space activities, and its research get the attention of all parties[1-5]. However, with the development of space technology and continuous improvement of modern robot manufacture technology, late-model space robot will progress in the direction of lightsome, high speed and high precision, and concerned dynamics and control problems on flexible space robot will become the hot topics for people to discuss. The flexibility of space robot system is mainly embodied in links of space robot and their connected hinge joints. For the reason of complexity of space robot system structure, researchers usually pay less attention on the system which both has flexible joint and link. Like some latest space robot plans from the United States, Japan, and Europe, they have required space robot not only just to do the simple auxiliary on-orbit assembly work for space station large components by tele-robot arm (Canada Arm) , but should have the abilities of satellite's orbit assembly, maintenance, repair, recovery, on-orbit fuel filling, orbit transfer, and space junk debris cleaning[6]. Under such situation, it should be taken into consideration that the influence of articulated joints flexible and link flexible against control accuracy which was ever been ignored in extensive operation, while now in the design of control system that required by space robot for high precision operation tasks.

So it's discussed in this paper for dynamics simulations, algorithm design of motion control, and active suppression problem of joint and link double flexible vibration for space robot system with flexible-joint and flexible-link under the situation of parameter uncertain. With the conservation relationship of linear and angular momentum, a system dynamics model is established by Lagrange equations, linear torsion spring and hypothesis modal method. To solve the problem that the application of traditional singular perturbation approach is limited by joint flexibility, a joint flexibility compensation controller is introduced, which can properly enhance the equivalent stiffness of joints. Then, based on singular perturbation theory, the whole system is resolved into flexible arm subsystem and motor moment power subsystem on the basis of joint flexible compensation controller and singular perturbation technology. An robust $\boldsymbol{H}_{\infty}$ control scheme is proposed for flexible arm subsystem, since tracking virtual desired trajectory, so rigid trajectory track is guaranteed just by inputting one control, and at the same time, active suppression on flexible vibration is made. And for motor moment power subsystem, a moment differential feedback controller is designed to inhibit system elastic vibration that caused by joint flexibility. Computer numerical simulation comparison experiment testifies the reliability and availability of this scheme.

References

[1]Rutkovskii V Y. Control of multimode manipulator space robot in outer space [J]. Automation and Remote Control，2010，71 (11) : 2345-2359.

[2]Li Junfeng, Wang Zhaolin. Study on attitude dynamics of a liquid-filled spacecraft with manipulators[J]. Journal of Astronautics, 1999,20(2):81–86 (In Chinese).

[3]Ge Xinsheng, Chen Liqun, Lv Jie. Nonholonomic motion planning of a space manipulator system using genetic algorithm [J]. Journal of Astronautics，2005,26(3): 262-266.

[4] Ding Xilun, Yu Yushu. A multi-propeller and multi-function aero-robot and its motion planning of leg-wall-climbing[J]. Acta Aeronouticaet Astronautica Sinica, 2010.31(10): 2075-2086.

[5] Liang Jie，Chen Li. Improved nonlinear feedback control for free-floating space-based robot with time-delay based on predictive and approximation of taylor series [J]. Acta Aeronouticaet Astronautica Sinica, 2012 , 33(1): 163-169.

[6]Lindsay E. Canadian Space Robotics on Board the International Space Station[C]//2005 CCToMM Symposium on Mechanisms, Machines, and Mechatronics. Montreal: Canadian Space Agency, 2005:26-27.