Spatial Operator Algebra for Free-Floating Space Robot Modeling and Simulation

TIAN Zhixiang* and WU Hongtao

Department of Mechanical and Electrical Engineering, Nanjing University of Aeronautics and Astronautics, Nanjing 210016, China

Received April 24, 2009; revised July 9, 2010; accepted July 30, 2010;

Abstract: As the dynamic equations of space robots are highly nonlinear, strongly coupled and nonholonomic constrained, the efficiency of current dynamic modeling algorithms is difficult to meet the requirements of real-time simulation. This paper combines an efficient spatial operator algebra(SOA) algorithm for base fixed robots with the conservation of linear and angular momentum theory to establish dynamic equations for the free-floating space robot, and analyzes the influence to the base body's position and posture when the manipulator is capturing a target. The recursive Newton-Euler kinematic equations on screw form for the space robot are derived, and the techniques of the sequential filtering and smoothing methods in optimal estimation theory are used to derive an innovation factorization and inverse of the generalized mass matrix which immediately achieve high computational efficiency. The high efficient SOA algorithm is spatially recursive and has a simple math expression and a clear physical understanding, and its computational complexity grows only linearly with the number of degrees of freedom. Finally, a space robot with three degrees of freedom manipulator is simulated in Matematica 6.0. Compared with ADAMS, the simulation reveals that the SOA algorithm is much more efficient to solve the forward and inverse dynamic problems. As a result, the requirements of real-time simulation for dynamics of free-floating space robot are solved and a new analytic modeling system is established for free-floating space robot.

Key words: nonholonomic constrained, spatial operator algebra, dynamic, free-floating space robot

---

* Corresponding author. E-mail: tzxnuaa@126.com
This project is supported by National Natural Science Foundation of China (Grant No. 50375071), and Commission of Science, Technology and Industry for National Defense Pre-research Foundation of China (Grant No. C4220062501).

E-mail: cjme@mail.machineinfo.gov.cn **http:** // www.cjmenet.com.cn