Paper ID: 38764
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student

SPACE OPERATIONS SYMPOSIUM (B6)
Interactive Presentations (IP)

Author: Mr. Kai Li
School of Aerospace Engineering, Beijing Institute of Technology, China

Dr. Yao Zhang
Beijing Institute of technology(BIT), China

A CONTROL METHOD OF TENDON ACTUATED LIGHTWEIGHT IN-SPACE MANIPULATOR BASED ON CABLE

Abstract

In-Space Manipulator is of vital importance to varieties of space missions such as on-orbit assembly, on-orbit propellant refueling, berthing of spacecraft, capturing and repairing of failed satellite, inspecting of spacecraft prior to atmospheric reentry. The typical applications of In-Space Manipulator are the Shuttle Remote Manipulator System and the Space Station Remote Manipulator System, which are considered as traditional manipulator architecture consisting of lightweight carbon composite tubes and heavy revolute joints. Some new missions like asteroid mining and asteroid redirection require much long reach manipulator, resulting in decreasing the packaging efficiency or increasing the total mass of manipulator. Therefore, the Tendon Actuated Lightweight In-Space MANipulator(TALISMAN) is developed. The architecture of TALISMAN includes link, spreader, joint, cable and motor, and it has the feature of lightweight, dexterous, modular and versatile. In this paper, we research on the TALISMAN system that consists of a central body and a TALISMAN that has four degrees of freedom. Firstly, Kane's method based on analytical mechanics is adopted to derive dynamic equations of TALISMAN system, where the central body and link are both considered as rigid body and the mass of cable is ignored. Meanwhile, the mass and the moment of inertia of spreader are equivalently converted into link. Thus, we obtain the nonlinear coupled dynamic model of TALISMAN system, which establish the relation between tension in cable and joint motion. Besides, the motion of central body and TALISMAN are interrelated. Secondly, a trajectory planning method of TALISMAN is given to get the motion of joint angle via the motion of endpoint of TALISMAN. The singularity of TALISMAN is considered in the process of trajectory planning and a method to get away from singularity is proposed. Thirdly, a PID controller is designed to achieve attitude stability of central body and trajectory tracking of TALISMAN. As a result of interrelation between central body and TALISMAN we must compensate the disturbance when design the controller. Last, the joint angles decide the configuration of TALISMAN and then the length of cable can be uniquely determined. So the motion of TALISMAN is related to length of cable and changing the length of cable could control the motion of TALISMAN. Therefore, we derive the equations between change rate of cable length and rotation rate of motor. The numerical simulation is also in progress.