Paper ID: 9796
oral
student

ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics - Part 2 (6)

Author: Mrs. Mengping Zhu
Beihang University, China, zmp831222@sa.buaa.edu.cn

Prof. Xu Shijie
Beijing University of Aeronautics and Astronautics (BUAA), China, starshijiexu@gmail.com

SPACE STATION ATTITUDE CONTROL/MOMENTUM MANAGEMENT CONTROLLER DESIGN BASED ON THETA-D TECHNIQUE

Abstract

Attitude Control/Momentum Management (ACMM) problem has been a dynamic research area stimulated by the rising research on large long-term manned space station. The aim of ACMM is to integrate the attitude control design and CMG momentum management, establish a proper tradeoff between station pointing and CMG momentum, slow down the accumulation of CMG momentum while satisfying the specific mission requirements. In this case, the space station is normally kept at an attitude which results in the sum of all external torques being zero and is defined as torque equilibrium attitude (TEA).

Considerable methods have been employed for ACMM, which fall into two groups: discrete and continuous. At present most attention has been focused on the continuous approach, which again can be divided as: linear, nonlinear, adaptive and robust. Among all these methods,the linear multiple loop Honeywell control scheme and the full state feedback, multivariable Johnson Space Center controller (JSC) have won the major interest for real implementation, with JSC being more preferable owning to its periodic-disturbance rejecting character. However, based on LQR theory, JSC is highly sensitive to the inertia property of the station. During the early stages of the station when momentum of inertia shifts significantly, the performance of the overall control system degrades. Thus proper gain scheduling or real-time gain computation is needed. But the computation load is enormous due to the fact that it has to solve the algebraic Riccati equation at each sample state.

In this paper, emphasis is on the continuous updating of the LQR gain through ϑ-D technique, which is a newly emerging nonlinear/linear suboptimal control method with greatly reduced online computation. First,the general three-axis coupled equations of motion of a rigid space station in a circular orbit are expressed in LVLH frame, following the linearization of the above equations, including the attitude-dependent aerodynamic, gravity gradient and gyroscopic torques, at the TEA point. The plant state equations are then augmented with general formulations of disturbance rejection filters. After a brief introduction of ϑ-D method, the augmented state equations are approximately changed into the ϑ-D form via perturbation method. The controller architecture for simultaneous attitude and momentum control is then presented.

The contrast of the simulation results between the original JSC controller and the regulator proposed here for a two-body system indicates that the ϑ-D based controller is excellent in performance with obviously less computation load compared to real-time computing of the Riccati equation.