Paper ID: 78134
student

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (2) (2)

Author: Mr. Haruta Miki
Tokyo Institute of Technology, Japan, miki.h.ab@m.titech.ac.jp

Dr. Toshihiro Chujo
Tokyo Institute of Technology, Japan, chujo.t.aa@m.titech.ac.jp
Prof. Saburo Matunaga
Tokyo Institute of Technology, Japan, Matunaga.Saburo@mes.titech.ac.jp

LARGE-ANGLE ATTITUDE MANEUVER OF VARIABLE-SHAPE SPACECRAFT WITH NONLINEAR MODEL PREDICTIVE CONTROL

Abstract

In recent years, as microsatellite missions are becoming more sophisticated, the requirements for attitude control performance are also becoming more demanding. In particular, rapid attitude maneuver and attitude stability are often required, but it is usually difficult to achieve both of them by microsatellites due to severe constraints on satellites' volume, weight, and power. We have therefore focused on Variable-Shape Attitude Control (VSAC), which can realize rapid and stable attitude control even under such constraints. In this method, the attitude of the satellite main body is controlled by driving other parts of the satellite, such as solar array paddles, utilizing the mass distribution change. An example of a satellite equipped with the VSAC is the 50-kg class microsatellite "HIBARI," developed at the Tokyo Institute of Technology. A serious of demonstration experiments of VSAC by HIBARI is currently underway in orbit.

In a previous study, a control law for VSAC was proposed, where the target angular acceleration is calculated by the quaternion feedback, and the paddle driving angle is commanded to the paddle controller such that it generates the target angular acceleration. However, this method has the following two drawbacks. First, it does not explicitly take into account the upper limit of the paddles' driving angular velocity and the driving angle range. Second, it is limited to a two-axis control ignoring the rotation around the third axis. In particular, large-angle attitude maneuvers of 43 degrees or more are difficult to achieve with conventional control methods, as they require paddle driving beyond the driving angle range. Therefore, this paper proposes a new control method that enables large-angle attitude maneuvers for spacecraft with variable shape capability.

Nonlinear model predictive control is introduced as a method to achieve large-angle attitude maneuvers. This control method overcomes the problems of conventional control methods and enables three-axis control, by explicitly considering the upper limit of the paddles' driving angular velocity and the driving angle range. In addition, this control method predicts the future response by solving the optimal control problem at each time step, so that a solution that enables large-angle attitude maneuvers can be sought. In this paper, numerical simulations show that large-angle attitude maneuvers of more than 50 degrees are possible by applying the proposed control method.