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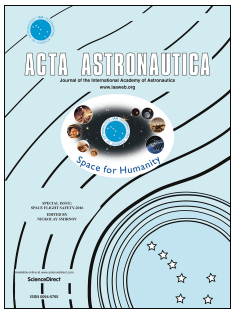

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Attitude Dynamics and Control of Spacecraft with a Partially Filled Liquid Tank and Flexible Panels

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Abstract: A liquid-filled flexible spacecraft is essentially a time-variant fully-coupled system, whose dynamics characteristics are closely associated with its motion features. This paper focuses on the mathematical modelling and attitude control of the spacecraft coupled with fuel sloshing dynamics and flexible solar panels vibration. The slosh motion is represented by a spherical pendulum, whose motion description method is improved by using split variable operation. Benefiting from this improvement, the nonlinear lateral sloshing and the rotary sloshing as well as the rigid motion of a liquid respect to the spacecraft can be approximately described. The assumed modes discretization method has been adopted to approximate the elastic displacements of the attached panels, and the coupled dynamics is derived by using the Lagrangian formulation. A variable substitution method is proposed to obtain the apparently-uncoupled mathematical model of the rigid–flexible–liquid spacecraft. After linearization, this model can be directly used for designing Lyapunov output-feedback attitude controller (OFAC). With only torque actuators, and attitude and rate sensors installed, this kind of attitude controller, as simulation results show, is capable of not only bringing the spacecraft to the desired orientation, but also suppressing the effect of flex and slosh on the attitude motion of the spacecraft.

Key words: Liquid-filled flexible spacecraft; Spherical pendulum; Assumed modes discretization method; Output-feedback attitude control

Nomenclature

A_{sp} = area of one panel, m^2

$\boldsymbol{A}_{B/O}$ = direction cosine matrix for the attitude motion of spacecraft

$\boldsymbol{A}_{P/B}$ = transformation matrix from the spacecraft body fixed frame to the pendulum fixed frame

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