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Title

Effects of Flexibility on Reorientation of Multibody Spacecraft Using Internal Torques

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Abstract

The use of internal torques that change the shape of multibody spacecraft while leaving their total angular momentum unaffected has been previously studied for reorientation and attitude control purposes. The problem of interest is that of nonholonomic control in which conservation of angular momentum provides a non-integrable constraint that can be mathematically formulated and leveraged to relate the attitude changes to those of the shape variables: in this case, defined by the angles between the spacecraft's appendages, assumed to be directly controllable via internal torques. Open-loop control torques can be subsequently designed by choosing a profile in the shape space, the attitude change resulting from which—known as a "geometric phase" [2]—can be expressed and numerically computed in advance.

Whereas the research in this area thus far has been on rigid systems, the authors' current work introduces flexibility. The kinematics and dynamics of the flexible problem are based on mathematical derivations to be presented in more detail in [1]. The focus of the present paper is on validation of the basics of the models and the corresponding Simscape™ simulations by reproducing the results (assuming negligible flexibility) for a fully rigid system—namely that in [3]—and then demonstrating the effects of large flexible deflections on the reorientation manoeuvres. Whereas [1] considers a central hub with large and heavy appendages (all bodies identical), uses multiple periodic loops in the shape space, and commands joint angle rates, the present work treats a more practical example with thinner appendages connected in a chain, uses a single rectangular shape profile, and provides angular accelerations. This enables the comparison of the results against those of [3]. In addition, [2] has a larger control aspect while the present paper primarily focuses on the dynamics, as well as their dependence on the system's configuration which becomes particularly important in the presence of flexibility.

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