ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics - Part 1 (5)

Author: Mr. Avishai Weiss
University of Michigan, United States

Prof. Ilya Kolmanovsky
University of Michigan, United States
Prof. Dennis Bernstein
University of Michigan, United States

INERTIA-FREE ATTITUDE CONTROL OF SPACECRAFT WITH UNKNOWN TIME-VARYING MASS PROPERTIES

Abstract

It is often both laborious and costly to determine the mass distribution properties of a spacecraft with the level of accuracy needed for precision attitude control. It is, therefore, of interest to employ control algorithms that are robust to such uncertainty. In prior work, we developed a method for inertia-free attitude control of a rigid spacecraft with a constant, yet unknown, inertia matrix. In this paper, we extend this approach to the case in which the inertia matrix is time varying. As such, the difficulty in modeling the inertia is exacerbated, and an inertia-free controller is even more desirable.

The mass distribution of a non-rigid spacecraft may be difficult to determine for various reasons. For example, a spacecraft may have articulated appendages or moving internal masses, the entire structure may change during docking and undocking operations, the spacecraft might be composed of multiple tethered rigid or flexible bodies, or the spacecraft's motion may induce internal fuel slosh. In all of these examples, the spacecraft's mass distribution and effective inertia change with time and are potentially unknown.

Some of the existing approaches to control non-rigid spacecraft include devising for specific structures, choosing to control the main body and dampening the appendages, or scheduling multiple controllers for a fixed number of configurations.

The continuous attitude tracking control algorithm derived in previous work requires no prior information on mass distribution. The algorithm provides a dynamic controller and incorporates internal states that can be viewed as estimates of the moments and products of inertia; however, these estimates need not converge to the true values in the case of a rigid spacecraft, and in fact do not converge to the true values except in cases of sufficiently persistent motion. This feature enables the algorithm to deal with non-rigid spacecraft. In this paper, we demonstrate the effectiveness of this approach.

Rotation matrices are used to parameterize attitude in order to avoid the need for discontinuous controllers, as are often used when the controller is based on quaternions.

Numerical simulation examples and case studies are presented that demonstrate that the algorithm succeeds at performing a variety of maneuvers for various non-rigid spacecraft, such as bringing them to rest, reorientation, or tracking a specified spin. We consider actuation based on both thrusters and reaction wheels.