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Author: Mr. Atilla Saadat
UTIAS Space Flight Laboratory, Canada

ON-ORBIT SPACECRAFT INERTIA TENSOR ESTIMATION

Abstract

Attitude determination and control algorithms may benefit from improved knowledge of the spacecraft inertia tensor. Generally, a spacecraft's CAD model is used to compute the inertia tensor, however, creating a very high fidelity model to capture numerous geometric configurations and small components such as tie-downs, wiring harnesses, fuel distribution, etc. is very time-consuming. Therefore, there is motivation to investigate methods for on-orbit inertia tensor estimation to improve attitude determination and control, without requiring detailed spacecraft solid models. In this paper, we propose a method of estimating the inertia tensor using high rate attitude sensor telemetry collected during a sequence of re-orientation maneuvers. Space Flight Laboratory's (SFL) high-fidelity attitude simulation software, MIRAGE, is used to simulate the spacecraft dynamics and environmental effects of SFL's DEFIANT spacecraft bus. Using MIRAGE, a custom attitude profile is created to excite the inertia tensor parameters while collecting magnetometer, sun sensor, rate gyro, and wheel speed telemetry. Spacecraft telemetry is then preprocessed to remove noise during periods of low angular acceleration. This data forms the input to an inertia tensor estimation algorithm based on the principles of conservation of angular momentum and constrained linear least squares. The estimation results are validated via comparison to the ground truth inertia tensor and stored inertia tensor. Estimation results demonstrate a <1% error for moments of inertia and <10% error for products of inertia using the spacecraft's true body rates. An in-orbit performance metric to assess the utility of the estimated inertia (in absence of a ground truth inertia tensor) and the degraded estimation performance with spacecraft telemetry body rates is also discussed.