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Author: Mr. Keenan Albee
Massachusetts Institute of Technology (MIT), United States, albee@mit.edu

Mr. Oliver Jia-Richards
Massachusetts Institute of Technology (MIT), United States, oliverjr@mit.edu
Mr. Alejandro Cabrales Hernandez
Massachusetts Institute of Technology (MIT), United States, cabrales@mit.edu
Mr. Antonio Teran Espinoza
Massachusetts Institute of Technology (MIT), United States, teran@mit.edu

BAYESIAN INFERENCE FOR DEPLOYABLE SATELLITE CONFIGURATION PREDICTION

Abstract

Deployable components can expand the capabilities of small spacecraft; deployable solar panels allow for greater power generation while deployable radiators can provide improved thermal control. However, activation of deployable components represents a significant source of mission failure due to the possibility of partial or complete failure for the component to deploy. Due to limited mass and volume, CubeSats and other highly constrained satellites might not be able to use extra sensors, such as cameras, to determine successful deployment and thus must rely on alternative methods.

This paper explores the use of Bayesian inference to determine if deployable components have been successfully deployed based on measurements of the spacecraft's angular position and velocity. The approach relies on the change in rotational inertia of the spacecraft as a deployable component is released. By examining the rotational dynamics of the spacecraft in the presence of applied torques, the rotational inertia of the spacecraft can be inferred thereby providing an estimate of if the deployable component was successfully deployed.

Bayesian inference maintains a description of the probability distribution function of the parameters of interest allowing one to describe parameter knowledge in terms of probability posteriors rather than a single most likely parameter estimate. As opposed to methods such as least squares, Bayesian inference provides a full probability density of the parameter of interest allowing uncertainty in the parameter to be quantified, a useful tool when drawing conclusions about hard-to-describe uncertain phenomena.

Markov-Chain Monte Carlo (MCMC), an algorithm used for sampling from posterior distributions, is used to model the configuration of a deployable satellite of interest using a forward model to describe configuration given satellite angular state histories. Using already available state histories from satellite slew, MCMC is able to produce a Bayesian description of the satellite configuration. The procedure is applied to a demonstration satellite of interest with deployable solar panels, SpinAp. In this case, two deployable solar panels on the 3U SpinAp CubeSat may have partially deployed and the algorithm is shown to produce a reliable prediction of possible satellite configurations. The method could be extended to more complex deployable satellite examples, such as the forthcoming James Webb Space Telescope.