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SOFTWARE ARCHITECTURE FOR DEEP-SPACE NAVIGATION FILTER DEVELOPMENT

Abstract

Autonomous navigation is essential for next generation missions in deep space where ground interaction is infeasible. Missions involving small-body flybys, target tracking and surface feature detection, autonomous landing, or touch-and-go maneuvers provide examples of applications that demand autonomous navigation. Additional interest has arisen in performing these missions with low-cost spacecraft in cubeSat or small satellite form-factors, which present additional constraints on the navigation problem. This work outlines a new modular software framework for the development and implementation of robust deep-space navigation filters in heavily hardware constrained contexts.

Traditionally, flight software has been developed to be mission-specific. However, recent adoption of flexible, modular software architectures has proved to improve efficiency. The advantages of flexible software architectures are compounded by mission proposals involving small spacecraft, whose intrinsic mass, power, and volume constraints require creative navigation solutions. An example of this can be found in the Deep Impact mission, which used a science instrument for navigation during approach phase and as a backup sensor during operations. This new paradigm of cost-limited space exploration demands agile flight software development. In this context, implementing analysis tools that rapidly assess the performance of given navigation hardware and software combinations, and iterate upon them, is critical for reducing mission design time and cost.

The focus of the present work is to design a modular and scalable architecture for autonomous navigation in smallsats using arbitrary sensor suites of interest. Trade-space considerations include, but are not restricted to: coupled attitude estimation and orbit determination, competition between science and GN&C for limited sensor time, different sensor types and availability, and in-flight interchangeability of both filtering strategies and dynamic models. The technical aspects of this paper will cover the specific module components, the interfaces between them as well as their relationships within the architecture. The proposed design will be implemented and validated within the Basilisk astrodynamics software framework.