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END-TO-END CONSTRAINED SPACECRAFT ATTITUDE OPTIMIZATION FOR RESIDENT SPACE OBJECT IMAGING

Abstract

In enhancing Space Situational Awareness (SSA), the precise imaging of Resident Space Objects (RSOs) is pivotal for accurate orbit determination of RSOs, which is foundational for maintaining the security and sustainability of space activities. This paper presents a novel approach for optimizing spacecraft attitude commands tailored for RSO imaging, a critical component in space-based optical imaging applications. Our approach can autonomously generate imaging missions for multiple RSOs based on an input list of NORAD IDs with specific spacecraft parameters within a predefined temporal window. The RSO imaging missions are optimized to select the best time to take an image per RSO mission from computed parameters, including relative in-plane velocity, imager exposure times, pixel occupancy, illumination factor, and relative distance. This optimization process is finely tuned to ensure compliance with operational constraints, notably avoiding star tracker exclusion zones for the Sun and Earth, enhancing the mission's operational lifetime, and increasing the Attitude Determination and Control Subsystem's (ADCS) pointing accuracy. The algorithm outputs autonomous satellite imaging mission commands for a spacecraft's imager and ADCS from the aggregate imaging missions. This paper also discusses and demonstrates the validation of the methodology through third-party spacecraft dynamics simulation software and on-orbit operations with Turion Space's Droid.001 spacecraft. The architecture of STARFIRE, Turion Space's proprietary automated end-to-end satellite operations framework integrated with optimized RSO imaging, is also presented. The implications of this research are significant for the future of space operations at Turion Space and other spacecraft operators. By enabling spacecraft to optimize their attitude for RSO imaging autonomously, we can enhance the quality and quantity of SSA data, thereby improving our ability to monitor and manage the space environment.