IAF SYMPOSIUM ON ONGOING AND NEAR FUTURE SPACE ASTRONOMY AND SOLAR-SYSTEM SCIENCE MISSIONS (A7)
Interactive Presentations - IAF SYMPOSIUM ON FUTURE SPACE ASTRONOMY AND SPACE PHYSICS (IP)

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ATTITUDE ESTIMATION STRATEGIES FOR CUBESPEC MISSION WITH A MULTI-STAR TRACKER ADCS

Abstract

Star trackers are the most accurate attitude estimation sensor. With current advancements in small satellite technologies, the pointing accuracy requirements are increasing for both commercial and scientific missions. CubeSpec is an in-orbit demonstration CubeSat mission to demonstrate high-spectral-resolution astronomical spectroscopy from a 6-unit CubeSat. The primary science demonstration case is to unravel the interior of massive stars using asteroseismology by high-cadance monitoring of the variations in spectral line profiles. Consequently, star trackers are essential satellite bus components. This paper examines attitude estimation strategies for a multi-star tracker ADCS for CubeSpec mission. Arcsec has previously developed an attitude-fusing library called Cerberus. Cerberus works as a driver for the different star trackers and fuses the attitude solutions to obtain an overall high accuracy estimate of the attitude. A Multiplicative Extended Kalman Filter (MEKF) smooths the quaternion estimates as they become available by different star trackers. Present work extends the Cerberus library to include direction measurements alongside the measurements of attitudes. The new methodology offers two main advantages. Fusing direction measurements enables Cerberus to incorporate fine Sun sensor and magnetometer measurements in the attitude estimation filter. Other attitude estimation algorithms such as generalized QUEST and nonlinear predictive attitude estimation are implemented and compared to MEKF based on accuracy and computational efficiency. As a side product, the new attitude filter propagates the centroid positions in the next images of the star trackers and predicts which star tracker will be blinded by the Sun or Earth. The attitude filter development includes the measurement error models of arcsec's star trackers, Sagitta and Twinkle. These models are verified to be representative of their performance for both direction and attitude measurements. Finally, both approaches of using full attitude or direction measurement strategies are tested by fusing different star cameras (one Sagitta and one Twinkle star tracker). The new methodologies are tested with both simulation and hardware-in-the-loop night sky tests. The simulations demonstrated 100