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ADAPTIVE KERNEL KALMAN FILTER ON LIE GROUPS FOR ATTITUDE ESTIMATION OF NANOSATELLITES

Abstract

Attitude estimation is a critical component in attitude determination and control systems (ADCS) for spacecraft from pico and nanosatellites all the way up to telecommunications platforms. While the accuracy and form factor of star trackers, the most accurate sensors used in attitude determination algorithms, has improved and the form factor and associated cost have decreased in recent times, they cannot be used continuously. Most commonly, sun-synchronous orbits present problems in positioning the star tracker prior to passes in direct sunlight. It is therefore of benefit to implement the latest nonlinear estimation techniques to maintain attitude knowledge during conditions where accuracy deteriorates. This paper presents an implementation of the recently developed adaptive kernel Kalman filter on Lie groups (AKKF-LG) to estimate the attitude of a nanosatellite. In this approach, the predicted and posterior distributions are estimated using kernel mean embeddings (KME) in reproducing kernel Hilbert spaces (RKHS). We extend the previous form of the filter defined in vectorspaces to Lie groups containing the attitude representation and gyroscope biases associated with a 3U Cubesat. A set of particles is generated and propagated in the Lie group tangent space before the kernel mean and covariance corresponding to the particle feature mappings are updated in the RKHS. The results are compared to the current state-of-the-art estimators including the Bayes-Sard Quadrature (BSQKF-LG) and invariant extended Kalman filters (IEKF) defined on Lie groups along with more the common multiplicative EKF (MEKF), unscented quaternion estimator (USQUE) and EKFs using Modified Rodrigues Parameters (MRPs). Since the AKKF-LG utilises a set of particles to capture the system dynamics, comparisons to more computationally intensive particle filters (PF) are performed. A broader analysis of computation time is performed to assess the viability of the AKKF-LG compared to the current state-of-the-art estimators.