Spacecraft attitude estimation from vector observations using a fast particle filter

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Abstract: A new algorithm is presented for the estimation of spacecraft attitude from vector observations. Belonging to the class of Monte Carlo sequential methods, the new estimator is a particle filter that uses approximate numerical representation techniques for performing the otherwise exact time propagation and measurement update of potentially non-Gaussian probability density functions in inherently nonlinear systems. The spacecraft attitude is represented via the quaternion of rotation. A genetic algorithm is used to estimate the gyro biases, allowing to estimate just the quaternion via the particle filter. This renders the new estimator highly efficient and enables its implementation with a remarkably small number of particles. Contrary to conventional filters, that have to address the quaternion's unit norm constraint via special (mostly ad hoc) techniques, the new filter maintains the quaternion's unit norm naturally, requiring no such modification. The results of a simulation study are presented, in which the new filter is compared to a conventional extended Kalman filter and to the recently proposed unscented Kalman filter in a case involving a low Earth orbit spacecraft, acquiring noisy Geomagnetic field measurements via a three axis magnetometer. The comparison demonstrates the viability of the new algorithm and its superior convergence rate relative to the alternatives.

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