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RAO-BLACKWELLIZED PARTICLE FILTER FOR THE CBERS-4 ATTITUDE AND GYROS BIAS ESTIMATION

Abstract

The Rao-Blackwellized particle filter (RBPF) and the Unscented Kalman filter (UKF) were developed in this work to attitude and gyros bias estimation using real orbit and attitude measurement data for CBERS-4 (China Brasil Earth Resources Satellite) recently in operation. CBERS-4 was launched in 2014, controlled and operated in shifts by China (Xi'an Control Center) and Brazil (Satellite Control Center). Its orbit is heliosynchronous with an inclination of 98.504 degrees, a semi-major axis of 7148.865 km, eccentricity 1.1×10^{-3}, crossing Ecuador at 10:30 am in a descending direction with perigee frozen at 90 degrees, which establishes a commitment relationship between a satisfactory amount of solar irradiance, contrast between targets, and the presence of clouds, and providing global coverage every 26 days. The real orbit and attitude measurements were provided by the Satellite Control Center of the National Institute for Space Research (CCS - INPE) for September 1, 2015. The dynamic attitude model is described by quaternions. The available attitude sensors are two Digital Sun Sensors (DSS), two Infrared Earth Sensor (IRES) and a triad of mechanical gyroscopes. The two IRES give direct measurements of roll and pitch angles with a certain level of error. The two DSS are nonlinear functions of roll, pitch, and yaw attitude angles. The gyros furnish the angular measurements in the body frame reference system. Gyros provide direct incremental angles or angular velocities, however gyros present several sources of error of which the drift is the most troublesome. Such drifts yield along time an accumulation of errors which must be accounted for in the attitude determination process. The RBPF estimation method used to attitude and gyros bias estimation is a technique that exploits the state space structure in order to reduce the number of particles, decreasing the processing time, avoiding the computational effort common to the standard particle filter. The logical extension of the RBPF provides a more general model that can be divided into purely non-linear and conditionally linear-Gaussian aspects, which explores this structure, marginalizing the conditional linear parts and estimating them using exact filters, such as the Extended Kalman Filter (EKF). The results show that it is possible to achieve precision in determining attitudes within the prescribed requirements using the RBPF, with lower computational cost when compared to the standard particle filter and its branches, in addition to having good results such as the UKF.