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Robust Double Gain Unscented Kalman Filter for Small Satellite

Attitude Estimation

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Abstract: Limited by the low precision of small satellite sensors, the estimation theories with high performance remains the most popular research topic for the attitude estimation. The Kalman filter (KF) and its extensions have been widely applied in the satellite attitude estimation and achieved plenty of achievements. However, most of the existing methods just take use of the current time-step's priori measurement residuals to complete the measurement update and state estimation, which always ignores the extraction and utilization of the previous time-step's posteriori measurement residuals. In addition, the uncertainty model errors always exist in the attitude dynamic system, which also put forward the higher performance requirements for the classical KF in attitude estimation problem. Therefore, the novel robust double gain unscented Kalman filter (RDG-UKF) is presented in this paper to satisfy the above requirements for the small satellite attitude estimation with the low precision sensors. It is assumed that the system state estimation errors can be exhibited in the measurement residual; therefore, the new method is to derive the second Kalman gain K_k^2 for making full use of the previous time-step's measurement residual to improve the utilization efficiency of the measurement data. Moreover, the sequence orthogonal principle and unscented transform (UT) strategy are introduced to robust and enhance the performance of the novel Kalman Filter in order to reduce the influence of existing uncertainty model errors. Numerical simulations show that the proposed RDG-UKF is more effective and robustness in dealing with the model errors and low precision sensors for the attitude estimation of small satellite by comparing with the classical unscented Kalman Filter (UKF).

Keyword: Attitude estimation; Kalman filter, UT; Model error; UKF

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