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Author: Mr. ASHOK KUMAR K
U R RAO SATELLITE CENTRE (URSC), India, kashok@ursc.gov.in

Mr. Chiranjib Guha Majumder
Indian Space Research Organization (ISRO), India, chiran@ursc.gov.in
Dr. MOHAN SUNDARA SIVA
U R RAO SATELLITE CENTRE (URSC), India, mssiva@ursc.gov.in
Ms. shubha kapoor
Indian Space Research Organization (ISRO), India, shubhak@isac.gov.in
Ms. Ritu Karidhal
Indian Space Research Organization (ISRO), India, ritu@ursc.gov.in

IMPROVING ON-BOARD ATTITUDE KNOWLEDGE ACCURACY BY REAL-TIME LEARNING AND COMPENSATION OF MEASUREMENT ERRORS FOR HIGH ACCURACY SATELLITES

Abstract

High Precision on-board attitude determination is essential for Earth Observation Spacecraft with very stringent pointing and stability requirements. The fusion of gyro and star tracker measurements in a state estimator is the commonly employed for spacecraft attitude determination. Sensor selection is based on estimates of knowledge accuracy attainable from a Kalman Filter (KF), which provides the optimal solution for the case of measurement and process errors characterized by random white Gaussian noise which are uncorrelated over time. Non-Gaussian geometrical and thermal errors in star sensor measurement arising from non-ideal star tracker characteristics, optical deformation and changing FOV, are significant and when left uncorrected (since these cannot be filtered out by six state Kalman filter), they get manifested erroneously as residual gyro drift estimates. These time varying drift estimates gets frozen during star sensor block out region which in turn results in uni-directional pointing error build up with non-zero residual rate

In this paper, to improve the attitude estimation accuracy, two stage approaches with pre-processing and filtering have been proposed. In first stage, star sensor low frequency spatial errors identification and compensation algorithm is proposed. The low frequency spatial error, which can be expressed by periodic basis function, is identified by the frequency spectrum of the estimated gyro drift, through multiple Fourier passes. Subsequently, compensated model of the low-frequency periodic error is established based on the identified parameters to improve the attitude determination accuracy. In second stage, Augmented Extended Kalman Filter (A-EKF) algorithm is proposed to further improve the attitude estimation after first stage. The attitude estimation accuracy of two stage approach is first demonstrated in digital simulations and subsequently with on-board data. The Augmented-EKF with periodic basis function measurement model derived from first stage identification algorithm shows the improvement in attitude estimation by about 10 to 15 percentage compared to traditional 6-state EKF in reducing the effects of temporally correlated systematic errors in the star sensor measurements.