SPACE EDUCATION AND OUTREACH SYMPOSIUM (E1)
In Orbit - Postgraduate Space Education (4)

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COMPARISON OF ATTITUDE ESTIMATION METHODS FOR PICO-SATELLITES IN LOW EARTH ORBIT

Abstract

Several attitude estimation methods has been designed during the development of AAUSAT4, which is currently undergoing the final preparation tests before launch. With the previously launched AAUSAT3 already in orbit, it is possible to collect sensor data directly from space in order to evaluate the performance of different attitude estimation methods in simulations using the measured noise variances. AAUSAT3 was launched February 2013, as a science experiment for the Danish Maritime Safety Administration, for monitoring ship traffic in arctic regions. AAUSAT4 is an extension of this science experiment with improved software and hardware for tracking ships. With accurate attitude estimation a better evaluation of the scientific payload will be possible than have been obtained with AAUSAT3.

The performance of different attitude estimation methods are tested with Monte Carlo simulations. The Monte Carlo simulations include; random initial attitude, velocity and time, variations of the satellite inertia matrix and on-board time, and finally the in-orbit sensor noise parameters obtained from AAUSAT3. A Matlab Simulink simulation environment developed for AAUSAT3 containing a reference model or "truth model" is used to test the estimation methods against, and to compare their individual performance and accuracy of attitude estimation. Here three methods in particular are examined: an SVD solution to Whaba's problem, an Extended Kalman Filter (EKF), and an Unscented Kalman Filter (UKF), both using an SVD-method as an initial guess. Computational complexity is examined for each of the attitude estimators, in terms of computational time and memory requirements.

The SVD-method has a poor attitude estimation performance, and in case of an eclipse occuring it fails completely to give an attitude estimate. The EKF-method has proven much better accuracy on the estimate compared to the SVD, at the cost of only a little more computational complexity. Further more, it does still perform attitude estimation when the satellite is in eclipse. The UKF proves to be slightly better than the EKF method, although at the cost of increased complexity.

It is apparent that the SVD-method is very susceptible to sensor noise and time drift in the on-board software. The EKF and UKF are both more robust to sensor noise and on-board software time drift, they

are both very influenced by changes or uncertainties in the satellite model. An SVD method is useful if an indication of the satellite attitude sufficient, if a more precise attitude estimate is necessary the UKF is a better choice.