Spinning Spacecraft Attitude Filtering with Spin Parameters: Performance Evaluation with Real Data

Halil Ersin Soken,[1*] Jozef C. van der Ha,[2] and Shin-ichiro Sakai[1]
[1]JAXA, Japan; [2]Satellite Mission Design and Operations, USA
ersin_soken@ac.jaxa.jp

Keyword : spinning spacecraft; attitude filtering; UKF; spin parameters

The spin-stabilization is one of the methods that have been used for spacecraft attitude stabilization since the early space era. Recently it has become attractive once more especially for the small satellite missions. The reason is its simplicity and suitability to conduct science missions at a relatively low cost. Nonetheless, attitude estimation for spinning spacecraft is not as simple as the method itself and may be even more challenging than that for the three-axis stabilized spacecraft.

Recently a nonlinear filtering algorithm specifically designed for spinning spacecraft attitude estimation was proposed [1,2]. The essence of the algorithm is representing the attitude of spinning spacecraft using a set of spin parameters which are the terms for the spin axis orientation unit vector in the inertial frame and the spin phase angle. This representation is advantageous as the spin axis direction terms in the inertial frame do not change rapidly and the phase angle changes with a constant rate in the absence of a torque. The results for the simulated data for JAXA's ERG (the Exploration of Energization and Radiation in Geospace) spacecraft show that the filter works well even with large propagation step size. It has similar or better accuracy than a filter with quaternions in state vector depending on the simulation conditions.

In this paper, we evaluate the performance of the algorithm with real data and investigate different methods for satisfying the spherical norm constraint for the spin axis orientation unit vector terms. We compare the results that filter gives with brute force normalization (BF) and Lagrange multiplier methods (LM) with the ones for an unconstrained filter (UC). The filter produces consistent results with those of the Tanygin-Shuster and TRIAD algorithms (Table 1). The norm condition for the filter is satisfied as long as the sensor data is good, even if we do not apply a specific normalization method (eg. BF or LM method). The norm error, which is the deviation of the norm for the estimates from 1, increases in the presence of bias in the measurements (Fig.1). In this case the Lagrange multiplier deviates from 0 to correct the spin axis direction estimates.

Table 1. Attitude estimation results using good sensor data.

Solution	**RA & DEC**	
TRIAD	258.6178	29.2575
T-S	258.6652	29.3423
SpinUKF (UC)	258.5938	29.2660
SpinUKF (BF)	258.5947	29.2657
SpinUKF (LM)	258.5947	29.2657

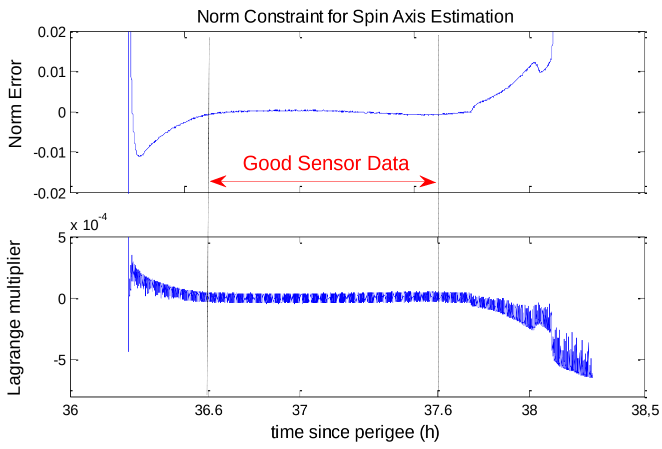

Figure 1. Variation of the norm error and the calculated Lagrange multiplier for spin axis estimation.

References

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