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A CALIBRATION APPROACH FOR SMALL SATELLITE MAGNETOMETERS CONSIDERING TIME-VARYING ERRORS

Abstract

A three-axis magnetometer (TAM) is as an essential attitude sensor for low-Earth orbiting small satellites. Being light, small and inexpensive make TAM an ideal attitude sensor specifically for nanosatellite missions. Nonetheless, it is a known fact that the accuracy of the TAM sensor suffers from the electromagnetic interference (EMI) onboard the nanosatellites. Thus several researches have been conducted for real-time estimation and compensation of the magnetometer errors caused by the EMI.

Recent studies show that on small satellites the magnetometer errors vary over time. In situ experiences with the launched spacecraft missions also confirm this fact. Variation in the magnetometer errors may be a result of the change in the state of the magnetic torquers and, interference from the nearby electronics and ferromagnetic materials (soft irons). Despite a number of researches about time-varying magnetometer errors, the calibration algorithms are usually applied ad hoc after the launch since the researchers lack information about the error characteristics. Besides only the variation in the magnetometer bias terms is considered and all other errors such as scaling are assumed to be time-invariant. Detailed analyses and experiments are needed to model the time-variation of the errors and to be able to distinguish the different error sources. A proper real-time calibration algorithm may be designed only after the error variation is understood clearly.

This paper is a sequel for our earlier paper presented at the IAC2017. In the first part the paper presents experiment results for an ongoing investigation which aims understanding the nature of magnetometer error variation on small satellites. A series of experiments are conducted to model the time-varying errors for small satellite magnetometer. In each experiment measurements are collected from an attitude sensor suite that is put on a 3 axes rotating test platform. The ferrous materials and a permanent magnet that is replicating the magnetic torquers are also placed on the platform in different test scenarios and their effects on the magnetometer measurements are investigated.

In the second part, a real-time calibration algorithm for the magnetometers is proposed. The algorithm estimates all the error terms including the scaling, nonorthogonality and bias terms for a full calibration. It uses other available attitude sensor measurements such as gyro measurements to both estimate the satellite's attitude and calibrate the magnetometers in real-time. The algorithm's accuracy is evaluated using the data collected from the experiment platform.