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HIGH PRECISE MASS CENTER ESTIMATION FOR GRAVITATIONAL WAVE DETECTION

Abstract

The detection of gravitational waves by satellites attracts scientists all over the world, and programs related to it like LISA, TIANQIN, TAIJI are in progress. Among the numerous technological challenges, mass center of the satellite should be estimated very precisely to meet the requirements of drag-free control and test mass acceleration analysis. Mass center of the satellite can be measured before launching; however, the drift still occurs because of severe launch vibration, fuel consumption, satellite temperature field variation et al.

To estimate mass center of the satellite precisely, the relative acceleration between the assumed mass center (the position of the accelerator) and the real mass center is used to derive the estimation equation. Via it, the estimation equation of the relative position between the assumed and the real mass center can be obtained after linearization. Micro-thrusters and magnetorquers are used as actuators, while gyros and accelerators are sensors. Regarding to the uncertainties of mass, forces of the micro-thrusters are specially designed, which do not result in the acceleration of mass enter in the ideal case. Both of orbital perturbations and noise of the actuators and sensors are considered. To obtain angular velocity of the satellite with better precision, predictive filter is designed and used. For the attitude motion, only angular velocity is measured by gyros, so quaternion and angular acceleration of the satellite are obtained by numerical integration and difference method with the known initial values. After all the parameters of the estimation equation are obtained, recursive least square (RLS) method is used to solve the equation in every step. Compared with other methods, RLS has low computation complexity, which is good for online computation.

In simulation, the time step for the dynamics of the satellite is 0.01 s while the sampling period of the measurements is 0.1 s. Numerical simulation results show that the with the use of predictive filter, higher precise estimated results can be obtained with the error of several millimeters. Moreover, better estimated results can be obtained with higher quality gyros and accelerators.