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AN AUTONOMOUS ORBIT DETERMINATION ALGORITHM FOR LUNAR PROBE USING GNSS SIGNAL

Abstract

With the rapid progress in spacecraft platform technology and the urgent needs for lunar exploitation, it is now feasible and necessary to build state-of-art small and less weighted payload to increase system functions as communication and measurement. One of the most important aspects in payload development is autonomous navigation using GNSS signal. Lunar probe vehicle life span depends on its orbit control capability. Orbit control is the ability of the vehicle to maintain orbit position and orientation during the mission period. Due to external perturbations, the trajectory of the space vehicle derives from the ideal orbit. Ac-tual positioning systems for satellites are mainly based on ground equipment, which means heavy infrastructures. Autonomous positioning and navigation sys-tems using Global Navigation Satellite Systems (GNSS) can then represent a great reduction in platform design and operating costs. However, GNSS signal with ap-plication to geosynchronous (GEO) and other high-altitude missions, especially the lunar probe missions has been limited to an experimental role because of the sparsity and weakness of the GPS signals present there. This paper proposed a novel adaptive orbit determination algorithm for lunar probe during the mission including lunar orbit transfer and near lunar period using GNSS signals. The adap-tive algorithm for model error is obtained by using an upper bound for the state prediction covariance matrix with augment of chi-square statistical hypothesis test in case of filter deteriorated by wrong residual information. The measurement noise is estimated at each filter step by minimizing a criterion function which was original from Huber filter. A recursive algorithm is provided for solving the crite-rion function. The proposed adaptive autonomous orbit determination algorithm was successfully implemented in one lunar probe mission using sparsity and weak GNSS signal. Simulation results demonstrated the promising performance of pro-posed orbit determination algorithm in robust and accuracy compared with pre-vious adaptive algorithms. This paper is the extension of author's previous re-search works in the field of nonlinear adaptive filter ([1] Xiaoliang Wang, Im-proved adaptive filter with application to relative navigation, GPS Solutions. [2] Xiaoliang Wang, et al., Improved adaptive Huber filter for relative navigation using global position system, Proceedings of the Institution of Mechanical En-gineers, Part G: Journal of Aerospace Engineering. [3] Xiaoliang Wang, et al., Laser radar based relative navigation using improved adaptive Huber filter, Acta Astronautica.), and some latest research results were provided.