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LINEAR MATRIX INEQUALITIES BASED ADAPTIVE FILTER FOR AUTONOMOUS NAVIGATION USING INTER-SATELLITE-LINK MEASUREMENTS

Abstract

With the development of Global Navigation Satellite System (GNSS) as GPS, GOLONASS, GALILEO and COMPASS, more concern is given to the GNSS's crucial function of autonomous navigation in case of Control Segment (CS) malfunction in the war. Autonomous navigation can be realized by using Inter-Satellite-Link (ISL) measurement with specially designed ISL antenna and receiver. Two major problems arise: prediction of Earth-Origin-Parameters (EOP) and suitable autonomous navigation algorithm onboard, and the later is more crucial since it provide precise ephemeris and clock information in an Earth-Centered-Inertial (ECI) reference frame. By using ISL measurements from each other, the orbit information can be obtained using Kalman filter. However, for typical GNSS design as Median Earth Orbit (MEO) with various orbit perturbations, a text-book dynamics model cannot accurately describe the real motion of the space vehicles for navigation filter design. Moreover, ISL measurement experience the unknown noises as clock stability, thermal noise, group delay, et al., some adaptive modifications should be augmented to the typical Kalman filter to incorporate those uncertainties. In this paper, an improved adaptive Kalman filter algorithm is presented to model error and measurement uncertainty. By using the theory of linear matrix inequalities, the adaptive algorithm for model error is obtained by using an upper bound for the state prediction covariance matrix. The measurement uncertainty is solved using the idea of bias characterization filter, which improves covariance fidelity in the presence of unknown measurement biases. The proposed adaptive filter algorithm was successfully implemented in ISL based autonomous navigation for GNSS. Software simulation results indicated that the proposed adaptive filter provide promising performance in robustness and accuracy compared with previous adaptive algorithms. This paper is the extension of author's previous research works in the field of nonlinear adaptive filter ([1] Xiaoliang Wang, Improved adaptive filter with application to relative navigation, GPS Solutions, Volume 15, Number 2, pp. 121-128, doi: 10.1007/s10291-010-0175-7. [2] Xiaoliang Wang, et al., Improved adaptive Huber filter for relative navigation using global position system, Proceedings of the Institution of Mechanical Engineers, Part G: Journal of Aerospace Engineering, July 2011 Volume. 225 no. 7, pp. 769-777, doi: 10.1177/0954410011399226. [3] Xiaoliang Wang, et al., Laser radar based relative navigation

using improved adaptive Huber filter, Acta Astronautica, Volume 68, Issues 11-12, June-July 2011, pp. 1872-1880, doi: 10.1016/j.actaastro.2011.01.002.), and some latest research results were provided.