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STOCHASTIC ASSESSMENT OF GPS OBSERVATIONS FOR LEO RELATIVE NAVIGATION

Abstract

Carrier-phase differential global positioning system (CDGPS) techniques have been playing an increasingly important role in high-precision spacecraft relative navigation. In kinematic spacecraft relative navigation data processing, algorithms are usually based on the least-squares principle for which both functional and stochastic models are always involved. The functional model is referred to as a linear or nonlinear equation which links the GPS observations to the unknown parameters. The stochastic model describes the accuracy of the observations and their mutual correlation with each other. Proper stochastic model estimation is of relevance for the choice of observation weights, which are collected in a weight matrix, allows one to specify by how much the individual observation should contribute to the overall solution. The previous works are usually based on considerable simplification, for example they usually assumed that all the single channel carrier phases or psedoranges have the same variance and they are statistically independent in space and time. In the present contribution, a more realistic stochastic model to GPS observations for LEO spacecraft relative navigation applications is formulated. This model presents the double-differencing introduced correlation between different channels, the correlation between different observation types, as well as temporal correlation of the measurements. The individual observation precision of each single channel is modeled using a predefined carrier-to-noise-power-density-ratio (C/N0) dependent model, which is more realistic than the usually used satellite elevation dependent model. Meanwhile, the temporal correlation is assumed to be various in the consequential epochs in order to make this model valid for space application where during the observation span, there will be rapid GPS satellites setting and/or rising. This GPS observations stochastic model is presented in a form of (co)variance matrix which has been written as an unknown linear combination of known cofactor matrices. The coefficients of this linear combination are then assessed by an iterated reweighted Least Square (IRLS) estimator. The efficiency of this estimator is investigated using truth-model simulation data of two formation satellites. Test results indicate that the precision of the estimated positioning is improved by applying the proposed stochastic model and assessment procedure. In addition, the reliability of the ambiguity resolution can be sufficiently improved.