

PROCEEDINGS

Distribution Transport: A High-Efficiency Method for Orbital Uncertainty Propagation

Changtao Wang¹ and Honghua Dai^{1,*}

¹Northwestern Polytechnical University, Xi'an, 710072, China

*Corresponding Author: Honghua Dai. Email: hhdai@nwpu.edu.cn

ABSTRACT

Orbital uncertainty propagation is fundamental in space situational awareness-related missions such as orbit prediction and tracking. Linear models and full nonlinear Monte Carlo simulations were primarily used to propagate uncertainties [1]. However, these methods hampered the application due to low precision and intensive computation. Over the past two decades, numerous nonlinear uncertainty propagators have been proposed. Among these methods, the state transition tensor (STT) method has been widely used due to its controllable accuracy and high efficiency [2]. However, this method has two drawbacks. First, its semi-analytical formulation is too intricate to implement, which hinders its promotion. Second, the solution flows and their Taylor expansion used to be solved by finite difference-based methods, which rely on small-step recursion, restricting the STT method's efficiency. To address these limitations, we propose a distribution transport technique based on STT, drawing inspiration from jet transport techniques [3,4]. By leveraging a mapping technique, the Taylor series expansion of the solution flows and higher moments in the STT formulation are organized into 'Transport Matrix' and 'Distribution Vector', which can be calculated automatically using polynomial algebra techniques. Furthermore, the computation of the solution flows' Taylor expansion is accelerated by the integration correction method, which solves nonlinear dynamic problems by parallel iteration in large steps [5,6]. The performance of distribution transport is validated in two classical nonlinear dynamics problems: the J2 perturbed two-body problem and the restricted three-body problem.

KEYWORDS

Orbital uncertainty propagation; state transition tensor; distribution transport; integration correction method

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