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Author: Dr. Yuichi Tsuda
Japan Aerospace Exploration Agency (JAXA), Japan, tsuda.yuichi@jaxa.jp

STATE TRANSITION MATRIX APPROXIMATION WITH GEOMETRY PRESERVATION FOR GENERAL PERTURBED ORBITS

Abstract

This paper presents a method for approximating the state transition matrix for orbits around a primary body and subject to arbitrary perturbations. Primary objective of this method is to provide an accurate state transition matrix for orbits with realistic perturbations which has a sufficiently simple form for implementation onboard spacecraft. A generalized averaging method is employed to isolate the high and low frequency spectrum of the perturbation terms, and construct a functional form of the approximate state transition matrix composed only of elementary analytic functions. In addition to the methodology of the approximation, it is shown that the symplectic property, which is a fundamental mathematical structure of Hamiltonian systems, can be incorporated into this method. This not only reduces the number of parameters required for approximations, but also preserves the physically true structure of the state transition matrix and provides some important properties that are practically useful for onboard computation. The resulting state transition matrix is expressed with a small number of constant parameter matrices and osculating orbit parameters at an initial epoch, and is valid for tens of orbital revolutions without having to update the parameters. Numerical simulations show that this method is valid for arbitrary eccentricity orbits with semimajor axis ranging from LEO up to around 10 Earth radii when applied to Earth orbits.