PDC 2017
Tokyo, Japan

☐ **Key International and Political Developments**
☐ **Advancements in NEO Discovery**
☐ **New NEO Characterization Results**
☐ **Deflection & Disruption Modeling and Testing**
☐ **Mission & Campaign Design**
☐ **Impact Consequences**
☐ **Disaster Response**
☐ **The Decision to Act**
☐ **Public Education and Communication**

Uncertainty Propagation in the N-body Problem using Dromo Elements

Javier Hernando-Ayuso[a,1,*], Claudio Bombardelli[b,2], Giulio Baù[c,3]

[a] *The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-8656, Japan, +81-(0)42-759-8322*
[b] *Technical University of Madrid, Plaza Cardenal Cisneros, 3, Madrid 28040, Spain*
[c] *Department of Mathematics, University of Pisa, Largo Pontecorvo 5, I-56127 Pisa, Italy*

Keywords: Covariance Propagation, Dromo, State Transition Matrix, N-body problem, Near Earth Asteroids

---

One relatively recent orbital motion formulation that may be very promising for uncertainty propagation is Dromo, proposed by Pelaez et al. in 2007 and considerably improved in subsequent works. It employs non-singular generalized orbital elements and a fictitious time derived from a second order generalized Sundman transformation. It has been shown to exhibit an excellent performance in terms of numerical propagation of orbits. In this paper, the Dromo formulation is considered for linear covariance propagation and its range of validity and performance is assessed using different classes of near earth asteroids (NEAs).

The first step in order to make the formulation applicable to covariance propagation in time is to modify it in order to have time as the independent variable. This step is crucial when the covariance propagation process involves time-dependent perturbations whose time-derivative need to be evaluated. The propagation of asteroid orbits, for instance, requires the computation of N-bodies gravitational perturbations obtained from time-dependent ephemerides. Next, one needs to construct a state transition matrix (STM) in Dromo elements and obtain the fundamental (linear) differential equation that governs its time evolution by computing the partial derivatives of the perturbing accelerations with respect to the Dromo state variables. Once the time evolution of the state transition matrix is obtained the covariance matrix propagation can be carried out analytically.

After completing the first two steps and providing all the required mathematical development for the numerical analysis we study a number of test cases in interplanetary space as an application of the proposed method. The evolution of the uncertainty of selected NEA's with different orbit condition codes (OCC) is studied comparing the results of a Monte-Carlo analysis with the linear propagation in Dromo elements as well as Cartesian coordinates.

---

*Corresponding author

Email addresses: javier.hernando@ac.jaxa.jp (Javier Hernando-Ayuso), claudio.bombardelli@upm.es (Claudio Bombardelli), giulio.bau@unipi.it (Giulio Baù)

[1] PhD Candidate, Department of Aeronautics and Astronautics

[2] Research Associate, Space Dynamics Group

[3] Research Fellow

Results show that the evolution of the uncertainty of asteroids of OCC 5 or lower can be represented quite well with the proposed method. Asteroids with very poorly known orbits (OCC 6 or higher) can be problematic especially in the presence of close approaches. As expected, the Cartesian representation of the covariance rapidly fails to represent the error distribution when propagated away from the initial epoch.

Comments:

Oral presentation preferred