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Author: Ms. Dhanisha Sateesh
Space Generation Advisory Council (SGAC), India, dha.tulip@gmail.com

Mr. Madhusudan Vijayakumar
Iowa State University, United States, msudan@iastate.edu

MULTIPLE FLY-BY LOW THRUST TRAJECTORY DESIGN USING FINITE FOURIER SERIES SHAPE-BASED APPROACH

Abstract

Studying small bodies like asteroids provides vital information in understanding our solar system's formation. The use of low-thrust propulsion for studying small bodies is becoming increasingly popular with notable sample return missions like NASA's OSIRIS-REx and JAXA's Hayabusa. One of the primary tasks of such a mission is designing low-thrust trajectories characterized by long flight durations. The task of a mission designer is to obtain both the magnitude and the direction of the thrust, which is usually obtained at discrete time steps. However, designing such low-thrust trajectories is challenging and time-consuming due to large search spaces. This problem is further compounded when gravity assists are involved. This paper builds upon the existing Finite Fourier Series (FFS) shape-based approach to present low-thrust planetary fly-by and rendezvous trajectories. The key point of this method is incorporating more free variables to characterize fly-by and enforce a constraint on the maximum thrust. This method rapidly evaluates the design space to generate feasible initial guess trajectories. The ability of this method to generate both planar and three-dimensional trajectories is demonstrated. A global search technique like the genetic algorithm is used along with the FFS to look for near-optimal solutions. The proposed method demonstrates the ability to generate fully automated trajectories with minimal manual tuning. The problem statement of the fourth Global Trajectory Optimization Competition (GTOC) is used as a benchmark to test the applicability of this method. The goal of the complex global optimization problem is to visit as many Near Earth Asteroids (NEAs) as possible with consecutive fast flybys and, finally, a rendezvous with an NEA. Finally, the solution generated by this method is validated on NASA's Evolutionary Mission Trajectory Generator. The authors plan to further extend this work to generate on/off thrust profiles to mimic bang-bang control.