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ROBUST TRAJECTORY OPTIMIZATION SOFTWARE USING DIFFERENTIAL DYNAMIC PROGRAMMING

Abstract

The Lunar Gateway is scheduled for construction in the 2020s. This is expected to accelerate deep space exploration, including beyond the Moon, particularly with the use of nano-satellites. A key challenge in this exploration is the optimization of multi-body and multi-revolution trajectory problems under low-thrust propulsion. Differential Dynamic Programming (DDP) has gained attention in recent years as a promising approach for trajectory optimization. However, several challenges remain: (1) a lack of available software for DDP-based trajectory optimization, (2) long computation times for solving multi-body problems, (3) increased computational demands when improving trajectory accuracy and achieving faster convergence, and (4) a high technical barrier that limits accessibility to experts. To address these issues, we are developing open-source trajectory optimization software utilizing DDP. Our approach focuses on:

(A) User accessibility – The software is designed for open-source use, with simplified installation and minimal dependence on the execution environment. It also includes comprehensive documentation and tutorials, making it more accessible to non-experts.

(B) Computational acceleration – GPU-based parallel computing significantly reduces computation times, addressing issues (2) and (3).

(C) Practical application – The software is tested on real-world trajectory optimization problems to validate its practical usability, ensuring it can handle complex mission scenarios.

The impact of (A) will be evaluated through pilot operations, and the latest findings will be presented at the conference. For (B), optimizations for the transition from GTO to GEO have shown a 100x speed improvement. For (C), we have verified that the software can solve not only two-body problems but also transitions from NRHO to LLO under the circular-restricted three-body problem (CR3BP). Through this research development, we aim to create a trajectory design environment accessible to a wide range of users, advancing deep space exploration.