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Corresponding author: Chang-Hun Lee
e-mail of corresponding author: lckdgns@kaist.ac.kr
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Entry Vehicle Trajectory Optimization using Convex Programming and Post-correction Technique

Authors
Jung CHEOL-GOO [1], Lee Chang-Hun [2], Kim Tae-Hun [3], Choi Hyung-Sik [4]*

** Corresponding author*
[1] Ph.D. Student, Korea Advanced Institute of Science and Technology, 34141, Republic of Korea, jjulgoo22@kaist.ac.kr
[2] Associate Professor, Korea Advanced Institute of Science and Technology, 34141, Republic of Korea, lckdgns@kaist.ac.kr
[3] Assistant Professor, Sunchon National University, 57922, Republic of Korea, thkim@scnu.ac.kr
[4] Senior Researcher, Korea Aerospace Research Institute, 34133, Republic of Korea, chs@kari.re.kr

Abstract
The objective of the entry guidance is to steer the direction of the aerodynamic lift so as to guide the space vehicle from its entry interface point(EIP) to specified final conditions. The entry guidance problem is identified as a challenging problem because of many entry path constraints as well as highly nonlinear dynamics. These inequality entry path constraints on heat flux, dynamic pressure, and load factor should be taken into account when developing the entry guidance. In the past, entry guidances rely on approximate, and heuristic methods to reduce the computational requirement. In [1], the entry guidance is designed based on an analytic solution of the equation of drag acceleration satisfying terminal conditions and constraints. An adaptive entry guidance algorithm is presented for mission planning and trajectory updates during the onboard mission in [2]. As computational power increases and efficient optimization algorithms evolve, trajectory optimization is gaining popularity in aerospace engineering applications such as guidance and path planning. The trajectory optimization method is a powerful tool for optimal control problems and can satisfy nonlinear dynamics and path constraints without relying on approximate and empirical relationships. Convex programming is one alternative for real-time applications because of its polynomial complexity and predictable and bounded calculation time. This paper proposes trajectory optimization using sequential convex programming and post-correction technique. The entry dynamics is reformulated with respect to energy over a spherical rotating Earth with entry path constraints by following [3]. The reformulated dynamics is approximated with a small flight-path angle assumption. The admissible control set is convexified utilizing exact relaxation for reducing the jitters in the control profile during the sequential solution process. To handle the problem of inconsistent linearization, additional slack variables are introduced in the quadratic trust region and augmented to the performance index for robust convergence. Then, dynamics is partially linearized and the solution is sequentially obtained using convex programming and post-correction technique with lagging the radial distance where the post-correction technique updates the coefficient of the dynamics nullifying the approximation error caused by the small angle assumption. Numerical simulations are performed to demonstrate the effectiveness and some of the notable aspects of the proposed method.

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