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INCREMENTAL SOLUTION OF LTMGA TRANSFERS TRANSCRIBED WITH AN ADVANCED SHAPING APPROACH

Abstract

In the last decade the global optimisation of low-thrust multi-gravity assist transfers (LTMGA) has been tackled with different approaches. Some authors proposed to generate a first guess solution by building a multi-gravity assist transfer with impulsive manoeuvres and then using a direct or an indirect method to transcribe the multi-impulse arcs into low-thrust arcs. Other authors, notably Petropoulos et al. (2002), De Pascale et al. (2006), Wall et al. (2008) and Schuetze et al. (2009), proposed the use of several forms of trajectory shaping to model low-thrust arcs. In particular Schuetze et al., proposed a deterministic branch and prune approach combined with multi-objective optimisation algorithm in which the low-thrust arcs were modelled with Petropoulos' shaping method.

In this paper we propose an extension of the work of Schuetze et al., preserving the idea of a deterministic branch and prune of the search space but improving the shaping. The shaping is improved in three ways: a) the shape of the trajectory is three dimensional, b) the shaping approach uses a mixed parameterisation blending spherical coordinates and orbital elements that allows accommodating a full set of boundary conditions both on position and velocity and a constraint on the thrust profile, and c) the local refinement with a feedback controller. Gravity assist manoeuvres are modelled with a linked-conic approximation assuming that a delta-v correction is allowed at the pericentre of the swing-by hyperbola (i.e., a powered swing-by model). The pruning of the search space is approached incrementally by adding one leg of the trajectory at the time and progressively removing subsets that do not satisfy a number of criteria (e.g. peak thrust, magnitude of the delta-v correction of the gravity assist manoeuvre, etc.). The process is conceptually equivalent to the approach proposed by Becerra et al. for the search space pruning of multi-gravity assist trajectories and exploits the decoupling of the transfer arcs offered by the powered swing-by model. Such decoupling removes the dependency of one arc from the preceding ones, and allows for pruning the search space in polynomial time even for low-thrust trajectories (as demonstrated by Schuetze et al.).

It will be shown that the computational time added by applying the pruning algorithm before performing an optimisation is compensated by the robustness of the optimization.