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ROBUST MULTI-OBJECTIVE TRAJECTORY OPTIMIZATION IN THE CR3BP

Abstract

Orbital mission analysis is an iterative procedure in which in principle an infinite number of solutions is tested until the one that best fulfils mission objectives is selected. With new missions defined in the Circular Restricted Three-Body Problem becoming more frequent, the mission analysis process for trajectories within this model must be improved. So far, most of the research efforts have been devoted to finding an algorithm that provides the minimum ΔV solution for a particular problem. This study presents a novel approach whose aim is to improve the initial phase of mission design by providing a multitude of optimal solutions that cover the majority of the trajectory possibilities. This should be performed without an initial guess input from the user, nor any kind of previously known solution, so that it can be applied to a wide variety of transfer problems.

In order to do so, the proposed research performs a multi-objective optimization on direct and manifold transfers simultaneously, and places the non-dominated solutions in a Pareto front. In this way, the user is able to easily choose which solution better meets the requirements in terms of ΔV and time of flight. Once the solution is chosen, it can be used as a first guess for a further optimization with the ASTOS software, which increases the accuracy and reliability of the results, by being verified in a higher-fidelity model using a n-body problem and continuous thrust arcs.

To achieve this purpose, the tool has been designed in collaboration with Astos Solutions GmbH and TU Delft, carefully selecting the design variables that completely define direct and manifold trajectories with the least amount of a priori information. Then MIDACO, a global search ant colony optimizer, is used to find the best solutions.

The results obtained include, for a sample case of a LEO to 9:2 resonance Earth-Moon L_2 NRHO, a Pareto front populated with optimal solutions, with a time of flight ranging between two and sixty days. Moreover, the overall process is fast, averaging a computational time in the order of a few hours for the cases analysed.