Abstract

The author has developed a suite of algorithms for solving the perturbed Lambert's problem in Celestial mechanics. These algorithms have been implemented as a parallel computation tool that has broad applicability. This tool is composed of four sub-algorithms and each provides unique benefits for solving a particular type of orbit transfer problem. The first one utilizes a Keplerian solver (p-iteration) for solving the unperturbed Lambert's problem. This algorithm not only provides a “warm start” for solving the perturbed problem but also helps to identify which of the several perturbed solvers is best suited for the job. The second algorithm solves the two-point boundary value problem (TPBVP) using a variant of the Modified Chebyshev Picard Iteration (MCPI) approach to solve for two-impulse Lambert transfers. This method converges over about one third of an orbit and does not require a Newton-type shooting method; no state transition matrix needs to be computed. The third algorithm makes use of regularization of the differential equations through the Kustaanheimo-Stiefel transformation and extends the domain of convergence over which the MCPI-TPBVP will converge, from about one third of an orbit to almost a full orbit. This algorithm also does not require a Newton-type shooting method. The third sub-algorithm uses the Method of Particular Solution (MPS) and MCPI to solve the perturbed two-impulse Lambert problem over multiple revolutions. MPS is a shooting method but differs from the Newton-type shooting methods in that it does not require integration of the state transition matrix. The mathematical developments that underlie these four sub-algorithms are derived in the chapters of this dissertation. For each of the algorithms, some orbit transfer test cases are included to provide insight on accuracy and efficiency of these individual algorithms. Following this discussion, the combined parallel algorithm, known as the Unified Lambert Tool, is presented and an explanation is given as to how it automatically selects which of the three sub-algorithms to use for solving the perturbed orbit transfer. The Unified Lambert Tool may be used to determine a single orbit transfer or for generating extremal field maps. A case study is presented for a mission that is required to rendezvous with two pieces of orbit debris (spent rocket boosters). The Unified Lambert Tool software developed in this dissertation is already being utilized by several industrial partners and we are confident that it will play a significant role in practical applications, including solution of Lambert problems that arise in the current applications focused on enhanced space situational awareness.

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