N-Impulse Orbit Transfer Using Genetic Algorithms

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Introduction

THE orbit transfer problems using impulsive thrusters have attracted researchers for a long time [1]. One of the objectives in these problems is to find the optimal fuel orbit transfer between two orbits, generally inclined eccentric orbits. The optimal two-impulse orbit transfer problem poses multiple local optima, and classical optimization methods find only local optimum solution. McCue [2] solved the problem of optimal two-impulse orbit transfer using a combination between numerical search and steepest descent optimization procedures. Jezewaski and Rozendall [3] developed an iterative method to calculate local minima solutions for the $n$impulse fixed time rendezvous problems. Genetic algorithms (GAs) have been used in the literature to search for the global optimal orbit maneuver. Reichert [4] addressed the optimum two-impulse orbit transfer problem for coplanar orbits only. The accuracy obtained using this formulation is not good unless a narrow range, around the optimal value, for each design variable is known in advance [4]. Given narrow ranges for the design variables, the solution obtained using this formulation does not guarantee that the satellite will be inserted exactly into final orbit, but rather there is a small error unless the GA finds exactly the global optimal solution. Kim and Spencer [5] introduced a different formulation to the two-impulse orbit transfer problem by using six design variables for coplanar orbits. This formulation also does not guarantee the satellite is placed exactly in the final orbit. In this note, a new formulation to the problem is introduced. This formulation is general for noncoplanar elliptical orbits. It can also implement any number of thrust impulses. For the case of twoimpulse maneuver, this formulation requires only three design variables for any noncoplanar orbit transfer. The solution obtained by this formulation is guaranteed to insert the satellite in the final orbit exactly, even if the GAs did not converge to the global optimal solution. This formulation requires solving Lambert's problem to find the parameters of the transfer orbit for a given set of the three design variables. The next section describes the orbit maneuver algorithm. The two-impulse transfer is considered a special case and is presented separately. Validation to this formulation is performed by solving several case studies to which the optimal solution is known.