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Automatic Trajectory Planning for Low-Thrust Active Removal Mission in Low-Earth Orbit

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Abstract

In this paper two strategies are proposed to de-orbit up to 10 non-cooperative objects per year from the region within 800 and 1400 km altitude in Low Earth Orbit (LEO). The underlying idea is to use a single servicing spacecraft to de-orbit several objects applying two different approaches. The first strategy is analogous to the Traveling Salesman Problem: the servicing spacecraft rendezvous with multiple objects in order to physically attach a de-orbiting kit that reduces the perigee of the orbit. The second strategy is analogous to the Vehicle Routing Problem: the servicing spacecraft rendezvous and docks with an object, spirals it down to a lower altitude orbit, undocks, and then spirals up to the next target.

In order to maximise the number of de-orbited objects with minimum propellant consumption, an optimal sequence of targets is identified using a bio-inspired incremental automatic planning and scheduling discrete optimisation algorithm. The optimisation of the resulting sequence is realised using a direct transcription method based on an asymptotic analytical solution of the perturbed Keplerian motion. The analytical model takes into account the perturbations deriving from the J_2 gravitational effect and the atmospheric drag.

Keywords: Active Debris Removal; Orbital Debris; Debris Mitigation; Automated Trajectory Design; Automatic Planning and Scheduling; Low-Thrust Transfers

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