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TRAJECTORY DESIGN FOR RETRIEVING NEAR-EARTH ASTEROID RESOURCES USING HIGH POWER SOLAR ELECTRIC PROPULSION

Abstract

This paper presents the low-thrust (LT) roundtrip trajectory design for retrieving near-Earth asteroid (NEA) resources using high-power Solar Electric Propulsion (SEP). A number of powerful deep neural networks (DNNs) are trained and optimized for 60 kW, 150 kW, 300 kW and 500 kW SEP-based LT trajectory design. DNNs are used as the surrogate of the conventional optimization process. A new low thrust trajectory roundtrip opportunity search algorithm is developed, which integrates the DNN models and allows an efficient roundtrip search process. Compared to the conventional approach, the DNN-based search algorithm reduces the search time by 99.96%. Assisted by these techniques, low-thrust roundtrip accessibility of all known NEAs (30,000) is investigated through a numerical approach and new knowledge of the mass transportation capability of SEP systems in NEA missions is provided. In total, 27.7 billion feasible roundtrip trajectories are stored in our database. For each NEAs, a low-thrust roundtrip mission opportunity map can then be drawn. It is found the 60 kW SEP can deliver 5 tons of supply to up to 40% of NEAs. Considering refueling on NEAs, the accessible NEAs can be further increased by 16.2%. It is suggested that the 150 kW, 300 kW, 500 kW SEP to be used to transport 10 – 30 tons, 30 – 70 tons, 70 – 120 tons resources from NEAs respectively. These mass ranges ensure about 4,000 or more targets to be accessible. Furthermore, the resource types on NEAs are preliminary determined by their taxonomy information. By combining the SEP LT accessibility analyses and the taxonomy information, it is also concluded that at least 41%, 33% and 27% of classified PGM-bearing, water-bearing, and silicate-bearing targets are accessible using SEP.