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MULTI-TARGET LOW-THRUST TRAJECTORY OPTIMISATION BASED ON ASTEROID CLUSTERING TECHNIQUE

Abstract

Currently, over 25,000 Near-Earth Asteroids (NEAs) and 1,000,000 Main-Belt Asteroids (MBAs) are recorded, and the numbers are still growing on a daily basis. The growing number of asteroids pose a challenge to multi-target low-thrust (LT) trajectory planning and optimisation. The purpose of this study is to develop an efficient multi-target low-thrust trajectory optimisation method based on asteroid clustering technique. The main idea is to plan the visiting sequences on clusters instead of on single asteroids, which will enhance the efficiency of planning. The moving asteroids will be modelled as a dynamic graph, where each node in the graph represent an asteroid. The distance matrix of the graph is measured by the low thrust transfer cost (e.g.: optimal time, optimal fuel consumption). By constructing such graphs, the asteroid clusters can be identified using unsupervised clustering techniques. The spacecraft rendezvous with any asteroid in a cluster will have feasible LT transfers to all other asteroids with a certain transfer cost. The identified clusters will be recorded and studied, where some of them are expected to be exist for years before disappearance. Therefore, the spacecraft that approaches any asteroid in a long existing cluster will have greater chance to visit multiple asteroids with a low cost. The trajectory planning will be implemented by optimising the visiting sequence between clusters and single asteroids inside the clusters. To the best of the authors knowledge, the proposed clustering based approach has not been presented in previous literature. One of the difficulties is to efficiently construct and update the asteroid graph based on a time step. To tackle this, a deep neural network (DNN) based classifier with 99% accuracy will be used to identify LT transfer feasibility of asteroids pairs in the graph. If a LT transfer is feasible, then a DNN-regressor will be used to estimate the cost of the LT transfer. The DNN models are able to process tens of thousands of data in seconds. The expected outcome of this work include the new multi-target low-thrust trajectory optimisation approach as well as the knowledges from the identified asteroids clusters.