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LOW THRUST TRAJECTORY OPTIMIZATION FOR MULTIPLE SPACE DEBRIS REMOVAL

Abstract

Low thrust trajectory optimization for the multi-target removal mission of sun-synchronous orbit space debris is studied in this paper. The space debris removal mission is that a 1000 kg spacecraft with the electrical propulsion system is launched to removal the space debris as many as possible among the potential 3629 debris, by resealing a 1 kg debris mitigation device near the debris, and the effects of J2 perturbation is considered. This problem is a longstanding challenging global optimization problem to design the best removal sequences and the transfer trajectories with very low thrust under J2 perturbation. In this paper, the debris removal sequences are determined by a pruning method under the pulse propulsion hypothesis, and an estimated equation of the energy and the relative elements is obtained to reduce the computation load. Once the removal sequences are established, a multiple homotopy method is proposed to accomplish the low thrust trajectory optimization between neighboring debris, which is constituted of three different homotoy methods with homotopic parameters embedded in the equations of motion and performance index respectively. Following this multiple homotopy method, the low thrust trajectory optimization problem can be easily solved after several iterative calculations, which takes a much easier problem with continuous and larger thrust magnitude under the linear gravity model as the initial starter. Finally, numerical demonstrations are provided, which illustrate that more than 100 debris can be removed with the designed low thrust trajectories by this proposed method.