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THREE-DIMENSIONAL OPTIMAL PATH PLANNING OF SWARM OF CUBESATS IN AN ASTEROID DETUMBLING MISSION

Abstract

The main objective of this paper is to design a swarm of CubeSats soft-landing missions on an asteroid surface with an irregular shape for asteroid de-tumbling purposes. The main issue in such sensitive space missions is optimal fuel consumption. Therefore, it is assumed that CubeSat's carriers are first taken by a mother ship to the equilibrium points of the asteroid. After that, the path of each swarm is optimized for a soft landing in the context of online agent collaboration. The goal of 3D optimal path planning for the swarm of CubeSats with limited thrust is to find the desired path without colliding in a three-dimensional strongly perturbed environment and to consider geometry, spatial and temporal constraints. In complex three-dimensional environments, there are many structural limitations and uncertainties such as asteroid gravity field, perturbations, etc. In this paper, the 216 Kleopatra asteroid is considered, which has relatively large dimensions and an irregular shape. The optimal landing point's position and attitudes are computed for de-tumbling the asteroid. Due to gravity model importance, the polyhedron gravity model is modeled, which is the most suitable model for asymmetric objects such as asteroids. The Particle Swarm Optimization Algorithm is used to optimize planned paths while maintaining the distance between the CubeSats to prevent possible collisions. Due to the context of online CubeSat's collaboration, the optimization algorithm could be able to re-program the surface landing points and CubeSat's path plans in the presence of any failure or challenge all through the soft landing mission. In order to evaluate the performance of the proposed mission, the sun-asteroid orbit is modeled and real data of asteroid is used for simulation. It is shown that the results from the optimization approach have appropriate accuracy in path planning of the swarm of CubeSats in the presence of environmental perturbations. Simulation results indicate that the performance of the used artificial intelligent method is significantly high for such a complex mission, particularly when the fuel consumption and time are limited so that it can be utilized to increase the accuracy of computations related to other explorations.