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Collision Avoidance Maneuvers Optimization Using Evolutionary Algorithms

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The exponential increase in the number of satellites in orbit in recent years has led to the generation of a congested space environment dominated by both active satellites and space debris. Therefore, collision avoidance maneuvers have become crucial to ensure the safety of space assets. Due to the fact that a satellite has a limited amount of propellant for maneuvering, and the importance of continously making orbital correction maneuvers, the constant performance of collision avoidance maneuvers with high fuel consumption can reduce the satellite's lifespan and therefore must be planned to optimize fuel consumption. This research addresses the application of evolutionary algorithms, specifically genetic algorithms, with the aim of determining an orbital maneuver that, given a scenario where there is a substantial risk of collision, minimizes this risk and presents lower fuel consumption.

Given that the space environment today has a complex dynamics, with several objects in orbit, the scenario where a satellite controlled by an operations center presents within a few days one or more conjunction events involving the asset and other objects is studied. Therefore, it is necessary to plan a maneuver that mitigates the risk of collision of each conjunction. This maneuver cannot also alter the satellite's orbit in such a way as to send it on a collision course with other objects. Thus, a genetic algorithm is implemented to optimize fuel consumption in the calculation of collision avoidance maneuvers, addressing a first scenario consisting of multiple conjunctions, however disregarding the possibility of the maneuver causing a conjunction with another object. Next, the problem is studied considering objects that orbit the surroundings of the satellite. For all cases, the metric that define a conjunction is the maximum probability of collision higher that a treshold established.

In relation to the maneuver, two different burn strategies are considered: the first being a single impulse in the tangential direction to the orbit at an instant before the first conjunction and the second strategy is the performance of two impulses (one before and another after the first conjunction) in a random direction (radial, tangential and perpendicular to the orbital plane).

References

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Poster