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A NETWORK-BASED RISK ANALYSIS FOR SPACE TRAFFIC MANAGEMENT

Abstract

Currently, more than 23,000 tracked objects orbit the Earth. While more than 90% of them is represented by debris and other uncontrolled objects, the number of satellites is consistently increasing due to a larger dependency on space-based services. This situation already accounts for hundreds of conjunction events each week, and several fragmentations per year adding new debris to the population.

In this work, we present a novel approach to analyse the overall collisional risk of the space resident population from a complex system perspective. Each object is represented by a node in a network. Links are established between two nodes whenever a conjunction between the corresponding occurs, and a weight is assigned to them based on the probability of collision. In order to study its global topology, the weighted network is analysed in terms of degree, centrality, clustering, and other metrics.

In addition, risk categories are defined by accounting for the consequences of a collision between objects alongside the probability of such an event. The severity of a collision is measured via its energy to determine whether the event is catastrophic or not. The weighted network is then refined to include the risk level in the analysis. Simulated fragmentations events can also be included in the evaluation.

Orbital data is taken from the NORAD database in the form of TLEs which are propagated via a high-fidelity propagator. Within this framework, we classify and rank objects by identifying those contributing the most to the overall collision risk.

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