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COLLISION RISK ASSESSMENT: AUTONOMY LEVELS FOR AI-BASED AUTONOMOUS COLLISION AVOIDANCE

Abstract

The collision risk assessment of space objects plays an important role in space situational awareness, particularly for conjunction assessment and collision avoidance. The rapid increase in the satellite population in the Low Earth Orbit (LEO) is causing the number of close approaches between operational spacecraft to increase sharply. The largest contribution to this substantial increase in space objects is made by mega-constellations such as OneWeb, Kuiper, and Starlink.

As part of the Artificial Intelligence for Collision Avoidance (AI4COLA) research group at Universität der Bundeswehr München (UniBw M), this study conducts an initial collision risk assessment within Starlink phase-1. As the phasing parameter determines the relative phasing between satellites in different orbital planes it thereby affects the relative position of the satellites in a constellation. This paper introduces a rating system for the analysis of the phasing parameter in terms of close approaches. The rating is based on the frequency of close approaches within a specific distance range, and the constellation is simulated for each value of the phasing parameter to find its best value based on the rating. The paper further discusses how the increase in the number of mega-constellations will impact instances of close approaches and, hence, evaluate and discuss the existing onboard artificial intelligence (AI) algorithms and their importance to help mitigate these risks by enabling satellites to autonomously avoid collisions through maneuvers. To this end, in light of the European Cooperation for Space Standardization (ECSS) standard for Space Segment Operability (SSO) for autonomous mission execution, this paper introduces autonomy levels for the AI-enabled autonomous collision avoidance operations of the satellite. These levels range from non-autonomous systems to fully autonomous systems, based on the pipeline of the standard collision avoidance procedures. The proposed autonomy levels offer a standard for using AI in specific parts of the pipeline to advance small research projects, improve interoperability and cross-platform compatibility among satellite systems, and provide a foundation for future AI-based autonomous collision avoidance efforts.