Paper ID: 79459
student

21st IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Operations in Space Debris Environment, Situational Awareness - SSA (7)

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TOWARDS REINFORCEMENT LEARNING-BASED COLLISION AVOIDANCE IN LOW-EARTH ORBIT: AN INITIAL STUDY

Abstract

The work presented in this paper investigates the use of reinforcement learning (RL) to address the growing threat of collisions between operational spacecraft and debris in Low-Earth Orbit (LEO). With the deployment of an increasing number of mega-constellations in LEO, the manual handling of conjunction events will soon become impractical. Hence, we must look for autonomous onboard solutions to be integrated into the collision avoidance pipeline. RL is a promising AI-based algorithm for this task due to its performance in complex problems and low online storage and computational costs.

The problem of COLlision Avoidance (COLA) is formulated in terms of the Markov Decision Process which is implemented in an RL environment using observation space, action space and reward functions. Different reward-shaping techniques are analyzed for an optimal solution. The proposed system utilizes a propulsion system with a discretized action space and is presented as a partial autonomy concept where the RL agent controls a satellite in a circular orbit in LEO that is on a collision pathway with debris. The RL agent plans an optimal COLA maneuver and the control policy for the maneuver is learned via the Proximal Policy Optimization (PPO) technique. Through this work, we aim to evaluate the effectiveness of the RL framework for COLA and provide insight into the potential benefits of autonomous systems for space missions. The results will contribute to the development of future LEO missions and ensure the safe operation of satellites in space. The resulting environment, with its tuned reward system and observational space, is to be developed further for more complex problems in the context of collision avoidance in the future.