52nd IAF STUDENT CONFERENCE (E2)
Student Conference - Part 2 (2)

Author: Mr. Arya Das
Indian Institute of Technology Kanpur, India

Dr. Dipak Kumar Giri
Indian Institute of Technology Kanpur, India

ROBUST AUTONOMOUS RENDEZVOUS, DOCKING AND FORMATION CONTROL OF ELECTRIC LOW-THRUST CHASER SPACECRAFT: A REINFORCEMENT LEARNING APPROACH

Abstract

In recent years, there has been a notable rise in the deployment of small satellites outfitted with efficient low-thrust electric propulsion systems. These satellites are increasingly utilized for complex missions that involve rendezvous, docking, and other close-proximity operations. In this context, Reinforcement Learning (RL) has emerged as a valuable tool for addressing the Guidance Navigation and Control (GNC) challenges of Rendezvous and Docking (RVD). RL, a machine learning approach, is adept at optimizing solutions for sequential decision-making problems, such as those encountered in RVD scenarios. In this paper, an optimal and robust approach to RVD has been presented using the reinforcement learning approach. Using Monte Carlo simulation analysis, we demonstrate that the RL approach can generate fuel-efficient rendezvous, docking and formation control trajectories. In case of low-thrust spacecraft, the rendezvous manoeuvres are not instantaneous impulses, but a prolonged continuous firing of the engine, which the RL approach successfully solves for. It satisfies constraints such as collision avoidance, approach cone constraint, and sensor line-of-sight constraint. We test it for navigation sensors noise and modelling noise and find that the developed model is robust to external disturbances, which further validates the approach. Safety, robustness, and reliability are big concerns for autonomous close-proximity operations. We envisage that owing to the robustness of the approach, this algorithm can be used for future close-proximity operations in space.