IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IP)

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

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

OPTIMAL FAR-RANGE RENDEZVOUS TRAJECTORY DESIGN OF LOW-THRUST ELECTRIC PROPULSION SPACECRAFT USING DEEP REINFORCEMENT LEARNING

Abstract

In recent years, there has been a significant increase in the deployment of small satellites equipped with efficient low-thrust electric propulsion systems. These satellites are being used for increasingly complex missions involving rendezvous, docking, and other close-proximity operations. In this context, Reinforcement Learning (RL) has emerged as a useful tool to solve the Guidance Navigation and Control (GNC) challenges of Rendezvous and Docking (RVD). In this paper, we present an RL-based approach to design fuel-optimal trajectories for far-range rendezvous of spacecraft. In this case, spacecraft equipped with low-thrust electric propulsion have been considered. Although there exists several RL-based RVD approaches in literature, we feel that little attention has been given to the far-range phase of rendezvous. Unlike conventional spacecraft where the rendezvous manoeuvres consist of impulses, in case of electric propulsion spacecraft they consist of long, continuous firing of the engines, sometimes over several weeks. Our proposed RL-based approach produces a trajectory of engine firings and engine pointing angles that optimally take the spacecraft to the destination. This process is made further challenging by the non-linear gravitational environment of cis-lunar and interplanetary space. Spacecrafts navigating in cis-lunar and interplanetary space also experience navigation and modelling errors, making the trajectory design process even more difficult. Hence, for a robust output, we perform high-fidelity simulations incorporating the above-mentioned errors. It is found that the proposed approach using RL produces near-optimal trajectories even in the presence of these disturbances. We envisage that the developed approach can be used on-board electric satellites performing autonomous operations in earth orbit, cis-lunar, or interplanetary space.