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Author: Mr. Carlo Cena
Argotec, Italy, carlo.cena@argotecgroup.com

Ms. Silvia Bucci
Argotec, Italy, silvia.bucci@argotecgroup.com
Mr. Alessandro Balossino
Argotec, Italy, alessandro.balossino@argotecgroup.com

DEEP REINFORCEMENT LEARNING FOR UNDER-ACTUATED SATELLITE ATTITUDE CONTROL AND REACTION WHEEL DESATURATION USING SOLAR RADIATION PRESSURE

Abstract

Future space exploration missions are expected to rely heavily on intelligent systems: communication latency and infrequent transmission windows, common in deep space, easily result in complex operations to control the spacecraft from the ground. Besides reducing time and costs for the missions, applying AI on-board has the potential to increase the reliability of spacecraft giving them the ability to autonomously react to unexpected disturbances or failures without compromising the mission. It has been shown that systems trained with Deep Reinforcement Learning (RL) can learn complex control behaviors by interacting with a simulated environment. In this paper we investigate the use of a model-free RL approach for nominal and underactuated attitude control of a small satellite (e.g., CubeSat) able to take advantage of the disturbance caused by the Solar Radiation Pressure (SRP) to perform reaction wheels desaturation and to control the satellite's attitude. Currently the SRP is considered in the attitude's control relying on mathematical dynamics and kinematics models of the spacecraft, susceptible to noise and modelling errors. We propose to use RL which is more robust to model errors and less costly to use during inference, both important advantages when considering the uncertainties and constrained computational resources typical of the space environment. The proposed approach utilizes a Neural Network to learn the optimal control policy to maintain a desired attitude using either 3 or 4 reaction wheels and the Solar Array Drive Assemblies (SADAs), while considering the torque generated by the SRP. The simulation results show that our approach can effectively control the attitude of the satellite in both the nominal and the underactuated scenarios demonstrating the robustness and effectiveness of the proposed approach in maintaining the desired attitude and performing desaturation while minimizing the resources required to perform these operations.