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COORDINATED MAGNETIC ATTITUDE CONTROL IN A SWARM OF CUBESATS: DEEP NEURAL NETWORKS FOR AUTONOMOUS OPERATIONS

Abstract

This study has been conducted as a part of the Skoltech University project to deploy a swarm of four 3U CubeSats in LEO. The principal objective of the mission is collective gamma-ray bursts or terrestrial gamma-ray flashes detection, which requires the satellites' coordinated attitude control. We consider a magnetic attitude control system actuated by three orthogonal magnetorquers in each of the spacecraft. The control algorithm to be implemented onboard is Lyapunov-based PD-controller. Usually attitude maneuvers relying on magnetic control are very sensitive to the values of the controller gains. These are tuned via a cumbersome procedure, which in one of its forms amounts to the derivation of linearized equations in the vicinity of the required attitude regime and subsequent numerical optimization (carried out in terms of Floquet theory and the degree of stability for the obtained system with respect to the controller gains). Normally the procedure is carried out on the ground and the gains are uploaded to the onboard computer from a mission control center. However, as the swarm mission implies a certain level of autonomy, we propose to consider the controller gains values as a function defined on SO(3), which can be approximated by a deep neural network. For this purpose, different architectures of networks are studied, their accuracy and performance depending on the training set are also taken into account. The implementation of the proposed approach is then showcased in a scenario when the swarm autonomously decides to direct its sensors with a limited field of view towards a certain event of interest in. These results are then compared with the results from spherical linear interpolation. Finally, benefits of further adaptation of the network's structure and weights based on the data collected during the mission are discussed.