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DEVELOPING ROBUST RENDEZVOUS AND PROXIMITY OPERATIONS CONTROL USING GENERATIVE-ADVERSARIAL MACHINE LEARNING

Abstract

Purpose: Controllers for spacecraft performing Rendezvous and Proximity Operations (RPO) must be carefully designed to guarantee both success and safety of the systems. As space missions move towards greater autonomy, especially autonomy in motion, validating the necessary behavior guarantees requires much greater effort. For designing a robust autonomous controller for spacecraft RPO, testing and simulation are helpful but cannot fully cover the enormous parameter space. GANs can provide more directed coverage than Monte Carlo alone.

Methodology: Generative Adversarial Networks (GANs) can help extend the utility of simulated data when applied carefully. The core idea of GANs is to split the problem between two co-trained learning networks with competing goals, a generator which attempts to produce "fake" data that is indistinguishable from the real data, and the main network which is learning to perform a task – e.g. classify images or control an autonomous system. This allows both a greater volume of training data for the primary machine learning model and an exploration of the problem space that might not be evident in available real data.

Results and Conclusions: By applying GANs to the design of an RPO controller, we can investigate the "long tails" of the problem – exactly the perverse parameter configurations that might thwart autonomous control. This allows greater robustness to as many factors as we allow the GANs to explore – component failures, parameter mismatch, actuation constraints, etc. and quantifies the vulnerabilities. Using GANs in controller design can provide novel and robust solutions to proximity operations in space.