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Maneuver Detection and Reconstruction in Data Sparse Systems with an Optimal Control Based Estimator

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The Big Sky Theory once posited that the volume of Earth’s orbital environment is so large that the chance of a collision ever occurring is effectively negligible. However, since 1996 six accidental collisions have been recorded in orbit, contributing thousands of trackable debris objects to this environment and possibly hundreds of thousands to millions more that are too small to track with current assets. Much of this debris persists to today. Access to this environment has become critical in our society, thus we need methods to ensure safe and continued access to it. Part of ensuring this is obtaining better information on its dynamics and its population. This research focuses on developing an automated approach to detecting and understanding the presence of mismodeled dynamics for orbital applications in order to provide more information on the objects in Earth orbit. We develop an algorithm called the Adaptive Optimal Control Based Estimator, which automatically tracks a target given observations, detects the presence of dynamic uncertainty, and reconstructs that mismodeling as an optimal control policy. These control policies may then be used to better understand the source of the mismodeling. Outside of a specific astrodynamics application, this algorithm attempts to fulfill a specific hole in the existing literature: automated, real-time estimation in dynamically mismodeled systems with data sparse and non-cooperative observation sets while obtaining information about the mismodeling. The development of this algorithm is shown, and several astrodynamics-based simulations demonstrate its ability to automatically detect and reconstruct dynamic mismodeling while maintaining tracking of the target.