Paper ID: 85846
oral
student

22nd IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Post Mission Disposal and Space Debris Removal 2 - SEM (6)

Author: Mr. Liam Field
University at Buffalo, United States

Mr. Grant Hecht
University at Buffalo, United States
Dr. Eleonora Botta
University at Buffalo, United States

SUCCESSIVE CONVEXIFICATION-BASED MODEL PREDICTIVE CONTROL FOR TETHERED DEBRIS DEORBITING

Abstract

The most promising method to dispose of large debris objects in LEO is active debris removal (ADR), in which an active spacecraft creates a physical interconnection between itself and the debris object. The resulting mechanical combination allows momentum transfer from the active craft to the debris and the subsequent removal of the debris via deorbiting. Amongst ADR methods, tether-based approaches have seen considerable attention due to the benefits provided by a flexible interconnection. However, further development of guidance and control algorithms for the deorbiting procedure in a tethered debris removal mission is needed.

Sequential convex programming (SCP) techniques provide an effective solution for onboard guidance, as seen, for instance, in application to powered descent. In this work, an approach to the guidance and control of a tethered debris deorbiting scenario - in which the tethered system is modeled as a planar dumbbell - is introduced based on successive convexification (SCvx), an SCP algorithm. Due to the expectation of disturbances and modeling errors, an MPC-like implementation of SCvx is used to track a reference trajectory composed of the orbital states, defined as the Keplerian elements of the system's center of mass. This reference is generated by solving a minimum-time single spacecraft deorbiting problem subject to a final periapsis radius constraint using SCvx. Tracking is then performed by solving a receding-horizon optimal control problem, again with SCvx.

This approach allows a single algorithm to solve the guidance and control problem of tethered target deorbiting under the dumbbell model. Currently, the SCvx-based MPC can track a minimum-time trajectory generated with direct collocation, requiring more fuel than the reference trajectory to account for motion in the local states. We will expand the current work by tracking references for the more relevant minimum-fuel problem. We will also introduce perturbations into the dynamics model, a necessary step to further evaluate the use of SCvx for guidance and control in the tethered debris removal mission. Finally, the planar dumbbell model will be modified to include target attitude dynamics to investigate the impact of their inclusion in the reference tracking algorithm.