Technische Universität Braunschweig

Study or Bachelor Thesis

Experimental Test of Spacecraft Proximity Operations with Motion Constraints using ELISSA Testbed

The amount of space debris in low Earth orbits (LEOs) has reached a key point where active debris removal (ADR) has to be conducted for space debris of high priority in order to ensure the sustainability of LEOs for future generations.

Spacecraft proximity operation is a key stage for ADR during which the chaser gets close to the target and may also need to synchronize its relative motion w.r.t. the target. During proximity operations, there are usually motion constraints on the relative (translational and rotational) motion of the chaser w.r.t. the target. These motion constraints include *collision avoidance constraint* to avoid the chaser colliding with the target, *field-of-view (FOV) constraint* on the relative rotational motion to ensure that the target stays in the FOV of the optical sensor on the chaser, and *approach path constraint* to avoid the chaser colliding with large appendages (e.g., solar panels) of the target during the final approach. To consider these motion constraints in proximity operations, one solution would be to introduce artificial potential fields (APFs) into the control algorithm.

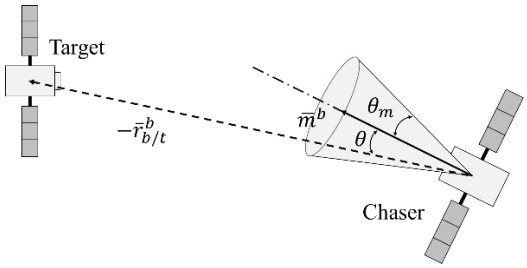

Figure 1. Field-of-view constraint

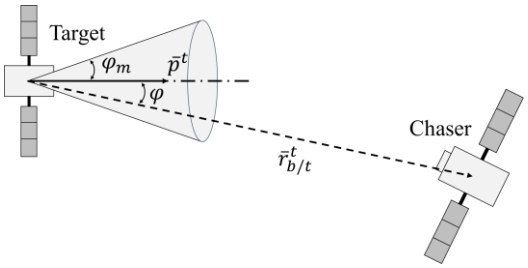

Figure 2. Approach path constraint

APF-based control algorithm based on sliding mode control (SMC) and dual quaternions has been developed at IRAS to consider those motion constraints. C++ codes for the developed algorithm are available. The algorithm has been validated using numerical simulations. The next step is to verify it using experimental test with hardware in the loop using ELISSA testbed at IRAS.

The focus of this project is on experimental test of spacecraft proximity operation with motion constraints using ELISSA testbed. Two mockups (called Hamilcars) developed at IRAS will be used as the chaser and the target spacecraft for the experiments. The developed APF-based algorithm for proximity operations with motion constraints will be validated. In detail the following tasks should be conducted during this study project:

1. Literature review on background of space debris, ADR, proximity operations with motion constraints, APF-based methods, etc.
2. Get familiar with ELISSA system and its operations
3. Get familiar with the APF-based algorithm used for the hardware-in-the-loop experiment
4. Integrate available C++ codes of APF-based algorithm into ELISSA system
5. Conduct experiments with settings of motion constraints (basically two scenarios)
6. Develop algorithm to avoid possible problems of local minimum of the current algorithm (based on related literature)
7. Analyze experimental data and results
8. Write the study thesis

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