Internship in ESA's Advanced Concepts Team

on

Autonomous exploration of a planetary system in the context of a robotic interstellar mission

Topic description

In a futuristic scenario a robotic interstellar spacecraft is to travel to, capture in orbit around, and explore a planetary system around its target star. The incomplete knowledge of the planetary system before launch and the very long communication times between spacecraft and Earth make autonomous operations essential [1]. Among others, two autonomous functions are necessary: a planning function to create an exploration plan able to achieve pre-set mission goals [2], and a trajectory optimization function to calculate optimal trajectories to visit the target sequences generated by the planning [3].

The goal of this project is to design, and prove the feasibility of a concept for the autonomous exploration of an unknown planetary system, in the context of a robotic interstellar mission. Methods from the fields of artificial intelligence and trajectory optimization are to be investigated and applied. A simulation tool will be created implementing the planning and trajectory optimization functions.

Candidate's tasks

- Create simple model of the autonomous planetary system exploration problem.
- Implement selected methods for each of the two necessary functions: autonomous planning and trajectory optimization.

The ideal candidate

Mandatory:

- Strong programming skills in Python.
- Understanding of artificial intelligence based search methods (e.g. graph- and tree search methods).
- Understanding of trajectory optimization methods.

Desirable:

- Familiarity with the interstellar mission design problem.
- Familiarity with autonomy, optimization, and/or mission analysis applications.

References

[1] A. M. Hein, S. Baxter, "Artificial Intelligence for Interstellar Travel", *Journal of the British Interplanetary Society*, 2019, https://arxiv.org/abs/1811.06526

[2] D. A. Surovik, D. J. Scheeres, "Reactive and Robust Paradigms for Autonomous Mission Design at Small Bodies", *Journal of Guidance, Control, & Dynamics*, 2017, https://arc.aiaa.org/doi/pdf/10.2514/1.G001902

[3] D. Izzo, D. Hennes, L. F. Simoes, M. Maertens, "Designing Complex Interplanetary Trajectories for the Global Trajectory Optimization Competitions", *Space Engineering*, 2017, https://arxiv.org/pdf/1511.00821.pdf