Internship in ESA's Advanced Concepts Team On Self-configuring cube ensembles

European Space Research and Technology Centre ESA ESTEC

Candidates interested are encouraged to visit the ESA website: <u>https://www.esa.int/gsp/ACT/about/jointheteam/</u>

To apply, visit: https://jobs.esa.int/job/Noordwijk-Intern-in-ESAs-Advanced-Concepts-Team/1001304601/

Topic Description

Recently, concepts for self-assembling and self-configuring structures in space have been proposed that have the potential to strongly reduce the deployment time and costs for space missions as well as to re-envision the morphology and functionality of space structures [1-4], e.g., by enabling in-orbit assembly and reconfiguration of structures from smaller, easily launchable components.

An example of such a technology - currently developed at MIT - is ElectroVoxels [1]: ensembles of connected cubes that can reconfigure into different shapes by performing tilting maneuvers along their edges (see [5] for an illustration). The objective of this internship is to develop a control algorithm based on modern reinforcement learning techniques that enables the autonomous reconfiguration of such ensembles from any initial configuration to any target configuration. Furthermore, we will investigate multi-agent reinforcement learning approaches, setting the foundation for fully decentralized control of cube ensembles, i.e., where each cube is its own reinforcement learning agent that acts autonomously.

Objectives

The objectives of this internship are:

1) Apply modern reinforcement learning techniques for controlling an ensemble of ElectroVoxels (in simulation).

2) Investigate these algorithms on different ElectroVoxel deployment scenarios and identify the most promising approach.

3) Review and perform initial tests of multi-agent reinforcement learning methods (and related approaches) to control the ensemble.

Joining the ACT

Creativity and out-of-the-box thinking are essential in the ACT. Therefore, the team is constantly striving to be a diverse, inclusive and equitable workplace bringing together people from various backgrounds. We strongly encourage people from under-represented groups to apply to be part of our team as diversity is central to our mission and core values.

In order to make our hiring as fair as possible, we also ask applicants to not include photos in their CVs.

References

[1] Nisser, M., Cheng, L., Makaram, Y., Suzuki, R. & Mueller, S. ElectroVoxel: Electromagnetically actuated pivoting for scalable modular self-reconfigurable robots in 2022 International Conference on Robotics and Automation (ICRA) (2022), 4254–4260. doi:10.1109/ICRA46639.2022.9811746.

[2] Ekblaw, A., Shuter, E. & Paradiso, J. A. Self-Assembling Space Architecture: tessellated shell structures for space habitats in AIAA Scitech 2019 Forum (2019), 0481. doi:10.2514/6.2019-0481.

[3] Pirat, C., Ribes-Pleguezuelo, P., Keller, F., Zuccaro Marchi, A. & Walker, R. Toward the Autonomous Assembly of Large Telescopes Using CubeSat Rendezvous and Docking. Journal of Spacecraft and Rockets 59, 375–388. doi:10.2514/1.A34945 (2022).

[4] Pehrson, N. A., Ames, D. C., Smith, S. P., Magleby, S. P. & Arya, M. Self-deployable, self-stiffening, and retractable origami-based arrays for spacecraft. AIAA Journal. doi:10.2514/6.2019-0484 (2020).

[5] https://www.youtube.com/watch?v=P_s28h0J7RA