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The German Aerospace Center DLR has a dual mandate as the national research center for aeronautics and space, and as the space agency of the German federal government. Approximately 9000 people work for DLR on a uniquely diverse range of topics spanning the fields of aeronautics, space, energy, transport and security research. They collaborate on projects extending from fundamental research to the development of the innovative applications and products of the future. If the idea of joining a top-class team of researchers working in a supportive, inspirational environment appeals to you, then why not launch your mission with us? The Institute of Communications and Navigation in Oberpfaffenhofen near Munich is offering a

Master Thesis

Decentralized Multi-Objective Swarm Formation Control

Your mission:

A swarm of autonomous rovers can rapidly explore a vast extraterrestrial area like in Figure 1. Compared to a single rover, a swarm can make simultaneous observations at different locations and avoids a single point of failure, which leads to a paradigm shift in future space missions. The movement strategy of rovers, assigned to autonomous exploration missions, are constrained by multiple objectives. Of course, the high-level goal is to collect information about the environment to be explored. Besides, the swarm needs to estimate the locations of itself and numerous objects, without the support of an external navigation system like GNSS. Further, the rovers' trajectories are constrained by terrain conditions. The swarm's unique capability of formation optimization has to account for all these objectives (and more), in order to successfully accomplish the exploration mission.

Formation control of a large swarm remained an open problem due to its high degree of freedom. In this thesis a framework for multi-objective swarm formation control should be develop, implemented and tested in simulations. The resulting algorithm is preferably decentralized, scalable, robust, and with low complexity and high precision. To this end, modern methods from the field of artificial intelligence may be applied.

Figure 1 Our research on swarm navigation promoted by the Proceedings of the IEEE.

Within this master thesis you are expected to contribute in:
- Survey on swarm formation algorithms and multi-objective optimization;
- Designing decentralized formation optimization algorithms, potentially with artificial intelligence (AI), to account for multiple objectives in an exploration mission
- Algorithm Implementation and demonstration within our swarm ecosystem.

Your qualifications:

- Excellent knowledge of positioning/tracking algorithms and wireless communication systems;
- Excellent mathematics/signal-processing background;
- Excellent programming skills in Python or C++;
- Preferable experience with ROS and PyTorch
- Self-motivated working and a good working knowledge of English

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