Universität Stuttgart
Institut für Flugmechanik und Flugregelung

Active SLAM for aerial robots

Master Thesis

Background:

Simultaneous mapping and localization has always been done passively. This requires that every robot needs a specialized trained operator to perform SLAM. This problem can be addressed with Active SLAM, which enables autonomous exploration of environments without human supervision. The result of the mapping can then be used in a variety of applications (e.g. inspection tasks, disaster sites, assistant robots).

Problem definition:

Our Active SLAM solution [1,2] consists of a three-layer framework that tries to optimize and influence every step of the exploration. The main source of information in our algorithm is the amount of entropy observable from a given point of view. Still, we have not yet tested our algorithm with aerial platforms, i.e. 3D navigation and exploration (see [3,4,5]). To this end, a study on how to efficiently do raytracing in a 3D world is necessary to compute the optimal heading in real-time. Indeed, if a ground robot that stands still does not use a high amount of energy, a drone hovering is depleting useful energy resources. Moreover, the whole pipeline needs to be adapted to 3D navigation, control, and optimization. Note that considering the 3D world gives an additional degree of freedom, but also new challenges in planning and optimization.

Task:

- Integrate a 3D navigation system and adapt the pipeline to flying robots.
- Research and develop a method to perform real-time 3D heading computation for Active SLAM.
- Develop the control approach (e.g. NMPC) to reach the waypoints.
- Test the approach and results both in simulation and real hardware.

Requirements:

- Interest in SLAM, control, navigation
- Experience with ROS / Gazebo desired
- Good problem-solving capabilities
- Experience with C++ / Python desired
- Good academic performance

If interested, please contact:

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[1] iRotate: Active Visual SLAM for Omnidirectional Robots,. https://arxiv.org/abs/2103.11641
[2] Active Visual SLAM with independently rotating camera, https://arxiv.org/abs/2105.08958
[3] Fast Frontier-based Information-driven Autonomous Exploration with an MAV https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9196707
[4] An Efficient Sampling-Based Method for Online Informative Path Planning in Unknown Environments https://arxiv.org/abs/1909.09548
[5] Uncertainty-aware receding horizon exploration and mapping using aerial robots https://link.springer.com/content/pdf/10.1007/s10514-019-09864-1.pdf