Universität Stuttgart
Institut für Flugmechanik und Flugregelung

Active SLAM for ground 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] consists of a three-layer framework that tries to optimize and influence every step of the exploration. We showed in [2] that this approach is used not only with omnidirectional platforms but also with other kinds of configuration. The main source of information in our algorithm is the amount of entropy observable from a given point of view. Still, we are not using *all* the information at our disposal, nor we have optimized the process. We think that tackling these two problems will result in faster and better exploration. For the former, a persistent 3D features distribution must be integrated into both the algorithm and the utility function. Then, to speed up the computation and finally apply the approach to a 3D navigation system, the procedure needs to be optimized. To this end, there exist approaches that use approximation techniques for raytracing and a parallel computation could be implemented. Moreover, a more careful design of the algorithm (for example by caching information) might be beneficial. A learning-by-demonstration approach might also be used.

Task:
- Research 2D map representations like variable voxel size [3].
- Develop a method to keep track of the distribution of the 3D features and incorporate those *directly* in the utility function.
- Research and develop a method to approximate the optimal heading and the path utility.
- Test the approach and results both in simulation and real hardware.

Requirements:
- Interest in SLAM
- Experience with ROS / Gazebo desired
- Good problem-solving capabilities
- Experience with C++ / Python desired
- Good academic performance
- In case learning for demonstration is of interest prior experience in the field is required.

If interested, please contact:
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[1] iRotate: Active Visual SLAM for Omnidirectional Robots, Bonetto et al.
https://arxiv.org/abs/2103.11641
[2] Active Visual SLAM with Independently Rotating Camera, Bonetto et al.
https://arxiv.org/abs/2105.08958
[3] Efficient dynamic occupancy grid mapping using non-uniform cell representation
https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9304571

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