Fast Frontier Detection for High-speed Exploration using Aerial Robots

Overview: This thesis aims to research new methods on fast and computationally efficient detection of the mapped space in order to facilitate high-speed autonomous exploration using agile aerial robots. In particular, the goal is to support Micro Aerial Vehicles in missions of autonomous exploration and mapping in environments for which no prior knowledge is available. Exploiting an online occupancy map representation of the environment the task is to first detect the frontiers of the explored space and then identify a dynamics-aware collision-free path towards that point in the robot's configuration space. We envision update rates that are fast enough for a robot to be able to fly with speeds as high as 5m/s, which in turn implies that the new path must be computed in very limited time by relying solely on the onboard computational resources.

Tasks and Sub-objectives

- Literature review - understanding of exploration path planning methods
- Literature review – understanding and evaluation of occupancy mapping frameworks
- Design and implementation of novel fast frontier detection algorithm
- Integration of the new method with an overall framework for autonomous path planning and guidance as implemented by the Autonomous Robots Lab.
- Verification in simulation using Gazebo/Ignition
- Deployment onboard the Resilient Micro Flyer robot (or other flying robot of our lab) and experimental evaluation

Starting Literature

[1] T. Dang, M. Tranzatto, S. Khattak, F. Mascarich, K. Alexis, M. Hutter, "Graph-based Subterranean Exploration Path Planning using Aerial and Legged Robots", Journal of Field Robotics, November, 2020, https://doi.org/10.1002/rob.21993, Videos: https://youtu.be/SNMsKAnCQkw , https://youtu.be/W9IgdmDg6UM. Open-Source Git Repo: https://github.com/unr-arl/gbplanner_ros

[2] Mihir Rahul Dharmadhikari, Tung Dang, Lukas Solanka, Johannes Brakker Loje, Dinh Huan Nguyen, Nikhil Vijay Khedekar, and Kostas Alexis, "Motion Primitives-based Path Planning for Fast and Agile Exploration using Aerial Robots", IEEE International Conference on Robotics and Automation (ICRA) 2020, May 31 - June 4 2020, Paris, France.

[3] A. Bircher, M. Kamel, K. Alexis, H. Oleynikova, R. Siegwart, "Receding Horizon "Next-Best-View" Planner for 3D Exploration", IEEE International Conference on Robotics and Automation 2016 (ICRA 2016), Stockholm, Sweden. Open-Source Git Repo: https://github.com/ethz-asl/nbvplanner

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[6] Keidar, M. and Kaminka, G.A., 2014. Efficient frontier detection for robot exploration. The International Journal of Robotics Research, 33(2), pp.215-236.