Chair of Software & Systems Engineering
TUM School of Computation, Information and Technology
Technical University of Munich

Master's Thesis Topic in collaboration with IABG

Development and Evaluation of Robust UAV Swarm Route Planner

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Starting Date:	As soon as possible

Context

The popularity of unmanned aerial vehicles (UAVs) has laid the groundwork for interest in cooperating UAVs. In particular, *swarms* of UAVs are the subject of many research efforts [1], including in applications related to surveillance and tracking. Swarms are typically groups of UAVs that are working together to achieve a common goal. As a *multi-robot system*, one of the ways that a UAV swarm can be characterized is by the way it is organized: when a single leader is giving instructions to all UAVs in the swarm, then the swarm is considered *strongly centralized* [2]. One of the general motivations for using swarms is to have a system that is robust to failures; if one UAV unexpectedly fails, the others will continue to operate and be capable of completing the swarm's task, although possibly with degraded performance [3].

Goal

This thesis topic will aim to (1) develop a swarm route planning system for a strongly centralized swarm, and (2) test the new route planning system in situations where one UAV stops functioning during the mission. Working with an industry partner, IABG, you will develop a swarm route planning system for a specific object tracking mission. The goal of the route planner will be to allocate goal positions (waypoints) to all the UAVs at all time-points such that the UAV swarm fulfills the mission of single/multi object tracking. IABG-developed simulation tools based on Airsim [4] will be used to design and implement the system. To test the system, you will design simulation-based experiments that show the performance and robustness of your implementation.

Working Plan

1. Use existing literature to build your understanding of strongly centralized swarms and route planners for UAVs. Concretely describe the mission scenario including the research questions you want to answer regarding the performance and robustness of your implementation.
2. Based on your findings in the literature, design and implement a route planner for the swarm (using e.g. search or optimization approaches).
3. Using the Airsim-based simulator, measure and evaluate your implementation's performance and robustness compared to an equivalent route-planning approach.
    - Performance: based on the quality of object tracking
    - Robustness: based on the change in performance when one UAV fails
4. Write the thesis document and prepare the presentation.

Deliverables

- Half-way point:
  - Draft of thesis introduction section describing the following: the research problem, the gap in existing literature, and your solution.
  - Short presentation to the advisors of this content.
- Final:
  - Thesis written in English and in conformance with TUM guidelines: comprehensively describing the methodologies, implementation, and findings.
  - Presentation of the work to the Chair.
  - Data / code as specified in the IABG contract.

References

[1] M. Abdelkader, S. Güler, H. Jaleel, and J. S. Shamma, “Aerial Swarms: Recent Applications and Challenges,” *Curr. Robot. Rep.*, vol. 2, no. 3, pp. 309–320, Sep. 2021, doi: 10.1007/s43154-021-00063-4.

[2] A. Farinelli, L. Iocchi, and D. Nardi, “Multirobot systems: a classification focused on coordination,” *IEEE Trans. Syst. Man Cybern. Part B Cybern.*, vol. 34, no. 5, pp. 2015–2028, Oct. 2004, doi: 10.1109/TSMCB.2004.832155.

[3] E. Şahin, “Swarm Robotics: From Sources of Inspiration to Domains of Application,” in *Swarm Robotics*, E. Şahin and W. M. Spears, Eds., in Lecture Notes in Computer Science. Berlin, Heidelberg: Springer, 2005, pp. 10–20. doi: 10.1007/978-3-540-30552-1_2.

[4] S. Shah, D. Dey, C. Lovett, and A. Kapoor, “AirSim: High-Fidelity Visual and Physical Simulation for Autonomous Vehicles,” in *Field and Service Robotics*, M. Hutter and R. Siegwart, Eds., Cham: Springer International Publishing, 2018, pp. 621–635. doi: 10.1007/978-3-319-67361-5_40.