WASP Project Course 2023

Path Planning and Autonomous Flight for UAVs

Background

This project focuses on autonomous exploration and path/motion planning in the context of search-and-rescue scenarios with unmanned aerial vehicles (UAVs). The project is conducted in collaboration with LUSA (Lund University School of Aviation), which runs the UAS Lab and testbed in Ljungbyhed and has access to controlled airspace for realistic autonomous flight experiments.

Field experiments are expected to be performed using the UAV platforms DJI Matrice 100 (WARA-PS) and DJI Matrice 300 RTK (LUSA). The UAVs are equipped with various sensors including a gimbal camera and/or thermal infrared camera, and an onboard SDK. The flights will be performed in a shared airspace. The project is performed in collaboration with WARA-PS, and in particular the group at the Department of Computer and Information Science, LiU (please refer to papers [1], [2]). WARA-PS already have an established team that has developed a simulation environment that can be used for testing, as well as analyzing the collected data.

Figure 1. Autonomous Flight experiments conducted in May outside of the Department of Automatic Control, Lund University

Constraints: Experiments will primarily be performed in Skåne County (available locations throughout the whole year), and possibly also in connection with the WARA PS event at Gränsö, Västervik (September).

Participants

Industrial partner: Combine, Lund University School of Aviation (LUSA)

Industrial supervisor: Stefan Ristevski, stefan.ristevski@combine.se

Academic supervisors:

Björn Olofsson, bjorn.olofsson@control.lth.se, Dept. Automatic Control, Lund University

Yiannis Karayiannidis, yiannis.karayiannidis@control.lth.se, Dept. Automatic Control, Lund University

Coordinating WARA representative:

Piotr Rudol, piotr.rudol@liu.se, Linköping University

Mariusz Wzorek, mariusz.wzorek@liu.se, Linköping University

Suggested WASP PhD students: Participants who are interested in working and applying their theoretical knowledge in the following areas: path/motion planning, control, localization, computer vision or object detection. All genuinely enthusiastic PhD students when it comes to the proposed project topics are more than welcome to participate, everything else can be learned.

Challenges to investigate

The problem itself consists of path/motion planning [3], [4], and control [5], [6], [7], and localization, with further possible extensions utilizing computer-vision techniques. This project provides research-oriented problems in the areas of path/motion planning and object detection in uncertain environments.

Various external disturbances acting upon aerial vehicles will have to be estimated, and the localization aspect will be touched upon as there is an interest to localize without the help of GPS. The project itself will be adapted to interests and suggestions from the project participants, while having an overall focus on autonomous flight in search-and-rescue scenarios.

Resources

- Support team from Lund University School of Aviation (LUSA) and WARA-PS
- Sensors (e.g., infrared sensors, GPS,…) – many possibilities upon request
- Control commands can be issued as speed/course/attitude angles at waypoints
- ROS interface possibilities, also included an onboard SDK with core code in C++ and python, easy SSH access from your own laptop
- Access and testing inside the already established WARA-PS simulation environment
- Support with data acquisition and software integration
- Experiments utilizing the help of LUSA pilots at various available locations and indoors based on the weather

Deliverables

- A project report has been prepared for the course, detailing the simulation and experimental results obtained during the project.
- An innovative path-planning algorithm specifically designed for the navigation of UAVs.
- Data-acquisition processes using LIDAR sensors, resulting in a dataset available for use after the project. Flight experiments incorporating wind compensation.

References

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[3] Zhou, B., Zhang, Y., Chen, X., & Shen, S. (2020). FUEL: Fast UAV Exploration using Incremental Frontier Structure and Hierarchical Planning. arXiv preprint arXiv:2010.11561.

[4] Zhou, B., Xu, H., & Shen, S. (2022). RACER: Rapid Collaborative Exploration with a Decentralized Multi-UAV System. arXiv preprint arXiv:2209.08533.

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Keywords

Path/motion and hierarchical planning, control, localization, computer vision, object detection, multi-agent planning, autonomous systems