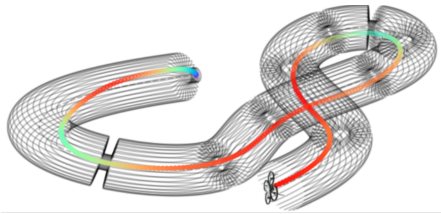
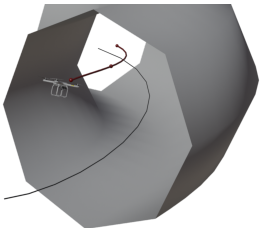
MSc. Thesis:
Safe flight corridor planning for agile navigation of quadrotors within dynamic environments

Contact: Jon Arrizabalaga – jon.arrizabalaga@tum.de
Starting date: As soon as possible (Winter-Semester 21/22)


Autonomous robotic systems are nowadays deployed in dynamic environments, where conditions and obstacles are time-variant. Successfully navigating under these circumstances, implies remaining within a safe and time-variant corridor. Seeking time-optimality, while guaranteeing the integrity of time-varying spatial bounds, is an appealing trade-off for agile vehicles, such as quadrotors.

In a prior project[1] we developed a real-time control that approximates time-optimal behavior, while simultaneously remaining within dynamic corridors. Simulated results demonstrate that our solution not only converges to time-optimality while navigating at high speeds – over $40\,\mathrm{m/s}$ – and performing aggressive maneuvers – up to $7\,\mathrm{g}$ –, but it also is eligible to stop or reverse if spatial bounds are abruptly modified.

This master thesis, intends to extend the aforementioned project with an algorithm that efficiently generates safe flight corridors within cluttered and dynamic environments by solely using onboard sensing and computation. Aiming to exploit the capabilities of this project, the candidate will have the chance to work side by side with a larger team of three people: two master thesis students working in the same project and similar topics and the constant support of the supervisor.

I. Research question

This thesis can be decoupled into the following two research challenges:

- development of a planner that efficiently finds a collision-free flight corridor within changing environments, without relying on prior computation or environmental knowledge and is compatible with receding horizon based controllers.
- integration and applicability of the planner with a perception system (such as RGB-D cameras), guaranteeing its integrity in the presence of sensor noise, motion blur or other imperfect measurements.

II. Our offer

The AAS Group is located at the newly founded TUM Campus in Ottobrunn (south of Munich) – next to many industrial partners. The campus is dynamically growing, interdisciplinary and offers the opportunity to shape the future of aerospace. We are offering

- the chance to work side by side with a larger team of three MSc students, focusing in the same project with similar topics,
- a vibrant and passionate research environment with four PhD students and one professor, willing to push the limits of autonomous drone navigation,
- the option to publish in top-ranked conferences,
- required hardware (drones, perception sensors, computation power, etc.) for running experiments in a flight arena with a motion capture system,
- delicious coffee.

III. Your skills

Besides passion for robotics and abstract thinking, candidates are expected to

- have a strong mathematical background with prior knowledge in path-planning and numerical optimization,
- be fluent in programming on Python and C / C++,
- have previous publications in conferences / journals (desirable, not mandatory).

IV. Application

Contact Jon Arrizabalaga at jon.arrizabalaga@tum.de, by attaching the following documents in English:

- Transcript of records
- Curriculum Vitae (CV)
- Motivation Letter describing why you are applying for this position and why you are the ideal candidate
- List of prior conference / journal publications, if available.

The starting date can be discussed, but preferably as soon as possible. The evaluation of the applications will continue until the position is filled.

[1] J.Arrizabalaga and M.Ryll, "Towards time-optimal tunnel-following for quadrotors", 2021. Online Available: `https://arxiv.org/abs/2110.01351`