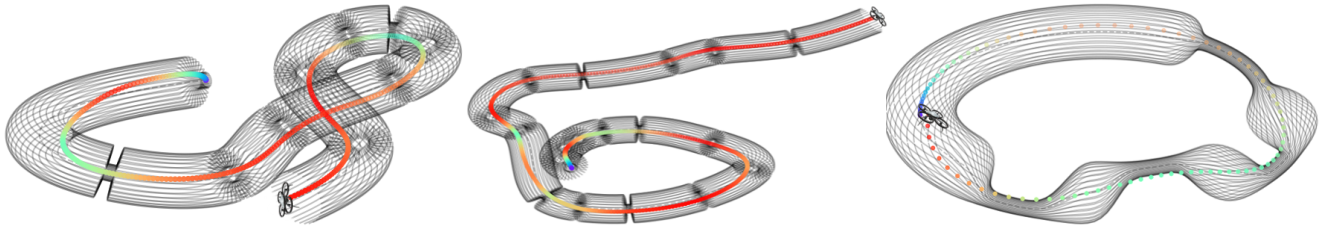
MSc. Thesis:
Economic NMPC for agile navigation of quadrotors within hazardous environments

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



Quadrotors are frequently used in space-constrained and time-critical operations, such as delivery, surveillance, inspection, and search-and-rescue. These are distinguished by the necessity of being time-optimal and subjected to strong environmental changes, where quadrotors need to deal with unforeseen disturbances.

Seeking time-optimality within such scenarios, we developed a real-time control[1] 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. However, the proposed approach lacks stability guarantees required for navigating in hazardous environments.

This master thesis, intends to extend the aforementioned project with a dual-objective NMPC scheme that first stabilizes the quadrotor's transverse dynamics, before maximizing progress along the path / corridor. Aiming to exploit the capabilities of this project, the candidate will have the chance to work side by side with a larger team of four people: three master thesis students working in the same project and similar topics and the constant support of the supervisor.

I. Research question

The research challenges comprised in this thesis are threefold:

- how to construct a lightweight, i.e. real-time applicable, dual objective-NMPC capable of stabilizing the quadrotor transverse dynamics, and sequentially exploiting progress along the path.
- how the presented controller performs against state of the art Transverse Feedback Linearizable - based linear controllers.
- how robust is the presented approach against extreme and unknown disturbances on the quadrotor.

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 limitless 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 special interest in control 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