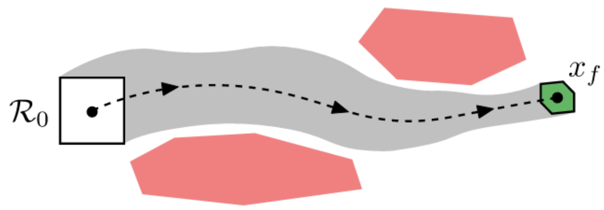
Control Benchmarking of Ship Models

Background

Autonomous ships are enjoying increasing attention, as innovations in this field will make the oceans safer for both crew and environment, while simultaneously reducing pollution. In contrast to autonomous driving, ship dynamics are often more complex, and thus finding a suitable controller often proves difficult. Still, the task at hand is quite similar: Both ship and vehicle have to reach a goal area, while also avoiding collisions with others.



Typical reach-avoid problem

That said, there is currently little research on applying and extending existing control approaches for autonomous vehicles to ships. In addition, existing approaches often do not produce formally verified results, which is crucial when a controller is applied in the real world and has to regard safety specifications.

Description

This thesis will address this research gap. To that end, we will research and integrate different ship models into the Automated Reachset Optimal Control (AROC) toolbox[1]. For each of these newly integrated ship models, we will evaluate the performance of AROC's various, formally verified control approaches on a simple reach-avoid problem, and compare them to unverified existing control approaches. Based on these simple, so-called motion primitives, we will then perform online motion planning, where we now consider static and dynamic obstacles.

Tasks

- Perform a literature review on ship models and related, specialized control approaches
- Familiarize yourself with the AROC toolbox and relevant control algorithms
- Compare the performance of the formally verified control approaches in AROC against unverified, specialized control approaches for each ship model
- Evaluate and discuss the benchmarking results
- *Optional:* Perform online motion planning using motion primitives

References

[1] Niklas Kochdumper, Felix Gruber, Bastian Schürmann, Victor Gaßmann, Moritz Klischat, and Matthias Althoff. AROC: A Toolbox for Automated Reachset Optimal Controller Synthesis. In *Proceedings of the 24th International Conference on Hybrid Systems: Computation and Control*, HSCC '21, New York, NY, USA, 2021. Association for Computing Machinery.

[2] Thor I Fossen. Mathematical Models of Ships and Underwater Vehicles. *Encyclopedia of Systems and Control*, pages 1–9, 2014.

[1] tumcps.github.io/AROC/

Technische Universität München

Fakultät für Informatik

Lehrstuhl für Echtzeitsysteme und Robotik

Supervisor:
Prof. Dr.-Ing. Matthias Althoff

Advisor:
Victor Gaßmann, M.Sc.
Hanna Krasowski, M.Sc.

Research project:
-

Type:
Bachelor's Thesis

Research area:
Control theory, reachability analysis

Programming language:
MATLAB

Required skills:
Good programming skills, interest in control theory

Language:
English or German

Date of submission:
2. Juli 2021

For more information please contact us:

Phone: -

E-Mail: victor.gassmann@tum.de; hanna.krasowski@tum.de

Internet: www.in.tum.de/i06

[3] Shuo Xie, Xiumin Chu, Chenguang Liu, Jialun Liu, and Junmin Mou. Parameter identification of ship motion model based on multi-innovation methods. *Journal of Marine Science and Technology (Japan)*, 25(1):162–184, 2020.

[4] Thor I. Fossen. A survey on Nonlinear Ship Control: from Theory to Practice. *IFAC Proceedings Volumes*, 33(21):1–16, 2000. 5th IFAC Conference on Manoeuvring and Control of Marine Craft (MCMC 2000), Aalborg, Denmark, 23-25 August 2000.

Technische Universität München

Fakultät für Informatik

Lehrstuhl für Echtzeitsysteme und Robotik