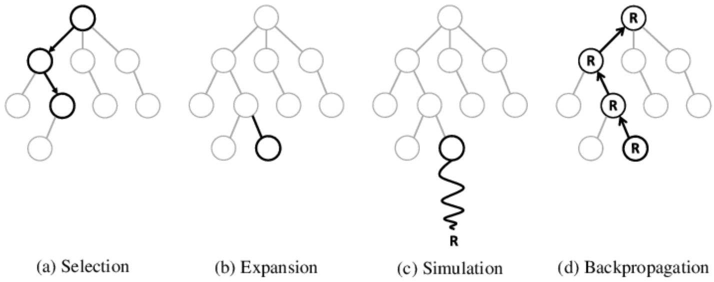
Computing Interaction-aware Reachable Sets of Automated Vehicles using Monte Carlo Tree Search

Background

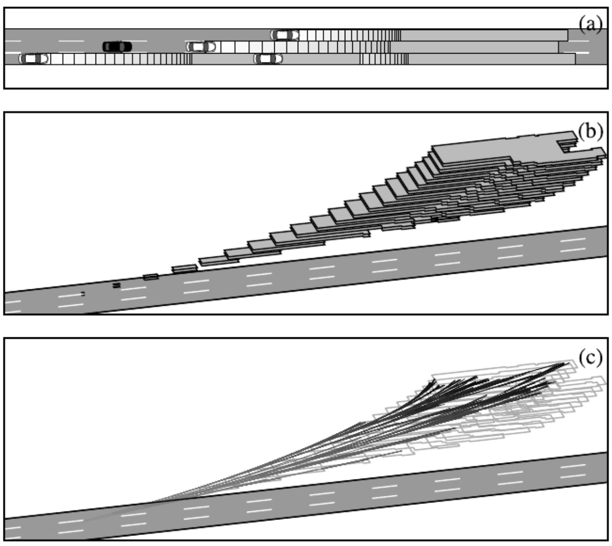
Highly-automated vehicles (AVs) promise an increase of road safety, time and cost efficiency compared to human drivers. Major challenges arise in dense, dynamic situations where the AVs should interact with human-driven vehicles. Game-theoretic approaches offer an elegant way tackle the interactions and dependencies between multiple agents. Based on certain assumptions, the ego agent can incorporate future interactions with other vehicles into its planning scheme. A decision process, such as using Monte Carlo tree search (MCTS), often realizes the game theoretic setting by sampling primitive actions. Surveys to MCTS can be seen here [1, 2].



Major steps in Monte Carlo tree search.

Description

The aim of this thesis is to compute interaction-aware reachable sets of automated vehicles using Monte Carlo tree search. The over-approximative reachable set [3] of a vehicle is the set of states that can be reached by the vehicle over time, and encloses all its drivable trajectories. The computed reachable sets can then be used as planning constraints for subsequent motion planning of the vehicle. The benefit of computing the reachable sets instead of the direct trajectory is that it allows for adopting arbitrary motion planner in the subsequent stage, as well as offer the possibility to negotiate reachable sets for a group of explicitly cooperating vehicles. An example of existing work of integrating MCTS into multi-agent cooperative motion planning can be seen here [4].



Reachable sets of a vehicle over time.

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Research project:
-

Type:
Master, Guided Research

Research area:
Reachability Analysis, Motion Planning, Monte Carlo Tree Search

Programming language:
Python

Required skills:
Above-average programming skill, highly-motivated, self-organized,

Language:
English

Date of submission:
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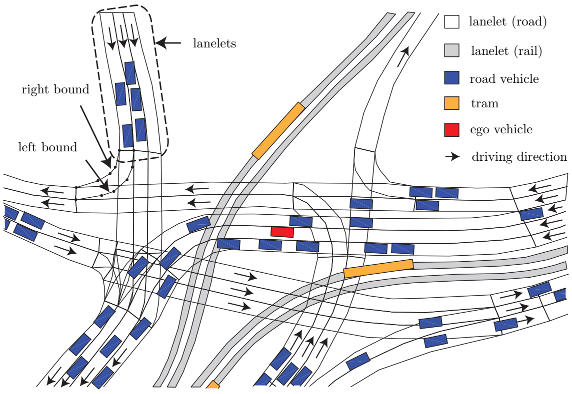
The results should be demonstrated with CommonRoad [5] scenarios, an exemplary of which is shown below.



An exemplary scenario from Stachus in CommonRoad

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Tasks

- Literature review on recent works on incorporating MCTS into motion planning.
- Familiarizing with CommonRoad and related software (reachable set computation, MCTS framework, etc.).
- Implementation of MCTS-based reachable set computation.
- Demonstration of computation results with various CommonRoad scenarios.
- Documentation of codes and other related materials.
- Thesis writing.

References

[1] C. B. Browne, E. Powley, D. Whitehouse, S. M. Lucas, P. I. Cowling, P. Rohlfshagen, S. Tavener, D. Perez, S. Samothrakis, and S. Colton, "A survey of monte carlo tree search methods," *IEEE Transactions on Computational Intelligence and AI in games*, vol. 4, no. 1, pp. 1–43, 2012.

[2] M. Świechowski, K. Godlewski, B. Sawicki, and J. Mańdziuk, "Monte carlo tree search: A review of recent modifications and applications," *arXiv preprint arXiv:2103.04931*, 2021.

[3] S. Söntges and M. Althoff, "Computing the drivable area of autonomous road vehicles in dynamic road scenes," *IEEE Transactions on Intelligent Transportation Systems*, vol. 19, no. 6, pp. 1855–1866, 2017.

[4] D. Lenz, T. Kessler, and A. Knoll, "Tactical cooperative planning for autonomous highway driving using monte-carlo tree search," in *2016 IEEE Intelligent Vehicles Symposium (IV)*. IEEE, 2016, pp. 447–453.

[5] Commonroad. https://commonroad.in.tum.de/.