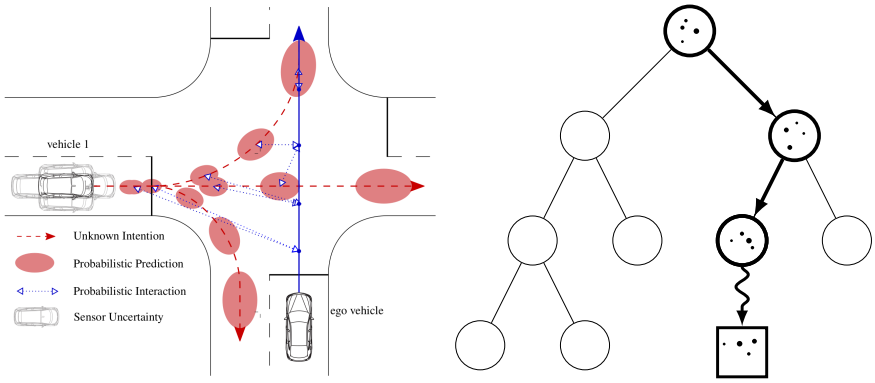
Karlsruhe Institute of Technology

Master Thesis

Combining Monte Carlo Tree Search with Reinforcement Learning for Decision Making under Uncertainty

A principal framework for decision making under uncertainty are Partially Observable Markov Decision Processes (POMDPs). Prior work has utilized POMDPs to plan stochastically in autonomous driving environments with incomplete information about other agents' intentions [1, 2]. The employed algorithms compute a solution online with Monte Carlo Tree Search (MCTS).
Another approach for solving planning problems with uncertainties is to use reinforcement learning (RL) [3, 4].



Intersection scenario with uncertainties [1] (left), MCTS (right)

This work aims at combining MCTS-based POMDP algorithms with RL. This can be accomplished e.g. by using a RL policy in MCTS rollouts. In this thesis, a problem from autonomous driving should first be solved independently with RL and MCTS to compare the approaches and then by combining the techniques.

This sounds exciting? Then apply to us! Methods and scope of the thesis can be adapted to your interests and previous knowledge. The proposed thesis consists of the following parts:

+ Literature research about reinforcement learning, Monte Carlo tree search and online POMDP algorithms
+ Implementation of autonomous driving scenarios in simulation for evaluating the approaches
+ Comparison of RL and MCTS-based POMDP algorithms
+ Combination of the two approaches
+ Evaluation of the implemented methods

I am happy to answer any questions you might have. Feel free to ask for an appointment or directly ask at my office!

References

[1] Hubmann et al., "Decision Making for Autonomous Driving Considering Interaction and Uncertain Prediction of Surrounding Vehicles", (2017)
[2] Bouton, Cosgun, and Kochenderfer, "Belief State Planning for Autonomously Navigating Urban Intersections", (2017)
[3] Tram et al., "Learning Negotiating Behavior Between Cars in Intersections Using Deep Q-Learning", (2018)
[4] Isele et al., "Navigating Occluded Intersections with Autonomous Vehicles Using Deep Reinforcement Learning", (2018)

Institute of Measurement and Control Systems (MRT)
Prof. Dr.-Ing. Christoph Stiller

Advisor:
Johannes Fischer, M.Sc.

Programming language(s)[1]:
Python / Julia — advanced

System, Framework(s):
Linux

Required skills:
- Solid mathematical foundations
- Work on your own

Language(s):
German, English

For more information please contact:

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Or directly send in your application including your current grades as well as our questionnaire!

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[1] **skill levels:**

beginner	< 500 lines of code (LOC)
advanced	500 – 5000 LOC
proficient	> 5000 LOC