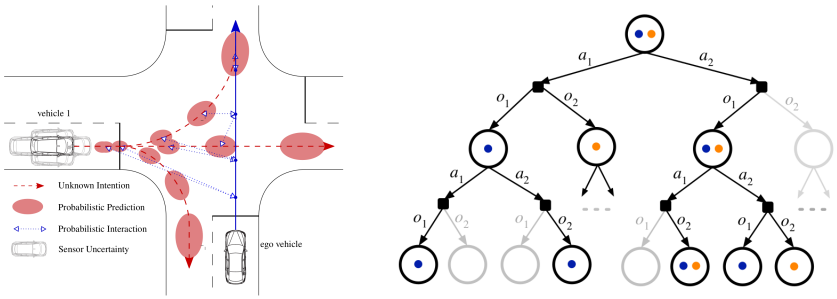
Karlsruhe Institute of Technology

Master Thesis

Decision Making under Uncertainty with MCTS-based online POMDP planning

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). A particular difficulty is to consider continuous observation spaces in the tree search.



Intersection scenario with uncertainties [1] (left), DESPOT tree [3] (right)

The DESPOT algorithm is another POMDP algorithm which is also based on MCTS, but additionally employs upper and lower bounds on the value function to build the search tree more efficiently [3].
In this thesis, the DESPOT algorithm and its recent derivatives (e.g. [4]) are to be applied to a planning problem in autonomous driving. To this end, new strategies for computing upper and lower bounds should be developed for the given problem.

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 online POMDP algorithms
+ Clear understanding of the DESPOT algorithm and its derivatives
+ Implementation of autonomous driving scenarios in simulation
+ Development of new strategies for computing upper and lower bounds
+ 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] Somani et al., "DESPOT: Online POMDP Planning with Regularization", (2013)
[4] Garg, Hsu, and Lee, "DESPOT-Alpha: Online POMDP Planning with Large State and Observation Spaces", (2019)

Institute of Measurement and Control Systems (MRT)
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Programming language(s)[1]:

Python / Julia	advanced
C++	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!

[1] **skill levels:**

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