Karlsruhe Institute of Technology

Master Thesis / Bachelor Thesis

Deep Reinforcement Learning with Transformer Networks as an Implicit Belief Representation

Automated vehicles have to deal with a multitude of uncertainties, including sensor noise, occlusions and unknown behavior of other traffic participants. A principal framework for decision making under uncertainty are Partially Observable Markov Decision Processes (POMDPs). Information from the past has to be considered to infer the unobservable states. This can be achieved by tracking a belief over the unobservable states.

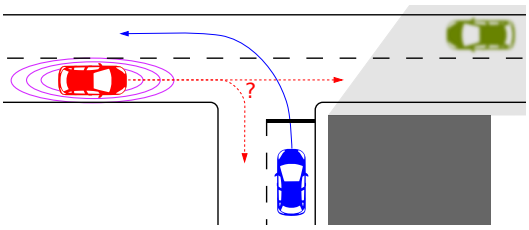

Illustration of uncertainties in autonomous driving

Prior work has modeled the planning problem of autonomous vehicles as a POMDP and solved it with reinforcement learning. They learn a policy based on the belief by using a recurrent neural network to subsume the past [1], explicitly tracking the belief [2] or by providing the whole history as input [3].
The transformer neural network architecture [4] is becoming more and more popular in various deep learning applications, even outperforming domain-specialized architectures like CNNs for images or RNNs for sequential data. It has also been used in the context of partially observable environments before [5]. This thesis should explore its applicability for belief space planning in a partially observable automated driving environment.

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 POMDP planning and transformer
+ Implementation of an automated driving POMDP environment
+ Implementation of suitable transformer architecture
+ Evaluation of the approach and comparison to prior work

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] Tram et al., “Learning Negotiating Behavior Between Cars in Intersections Using Deep Q-Learning”, 2018
[2] Bouton et al., “Reinforcement Learning with Iterative Reasoning for Merging in Dense Traffic”, 2020
[3] Kamran et al., “Minimizing Safety Interference for Safe and Comfortable Automated Driving with Distributional Reinforcement Learning”, 2021
[4] Vaswani et al., “Attention Is All You Need”, 2017
[5] Esslinger, Platt, and Amato, *Deep Transformer Q-Networks for Partially Observable Reinforcement Learning*, 2022

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

Advisor:
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Programming language(s)[1]:
Python or 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!

[1] **skill levels:**
beginner < 500 lines of code (LOC)
advanced 500 – 5000 LOC
proficient > 5000 LOC