KI WISSEN
Automotive AI Powered by Knowledge

2.1 Informed Motion Planning

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Trajectory Prediction and Motion Planning

Traffic Rule Aware Motion Planning

We developed methods for the integration of rule knowledge into maneuver decisions and trajectory planning. We focused on the inclusion of knowledge in the form of traffic rules and physical constraints during training.

Gathering Knowledge on Road User Behavior

Prior to the inclusion of knowledge we wanted to gain a better understanding of real-world road user behavior given certain traffic rules. For this, we performed a large-scale analysis [1] of the Waymo Open Motion dataset [3].

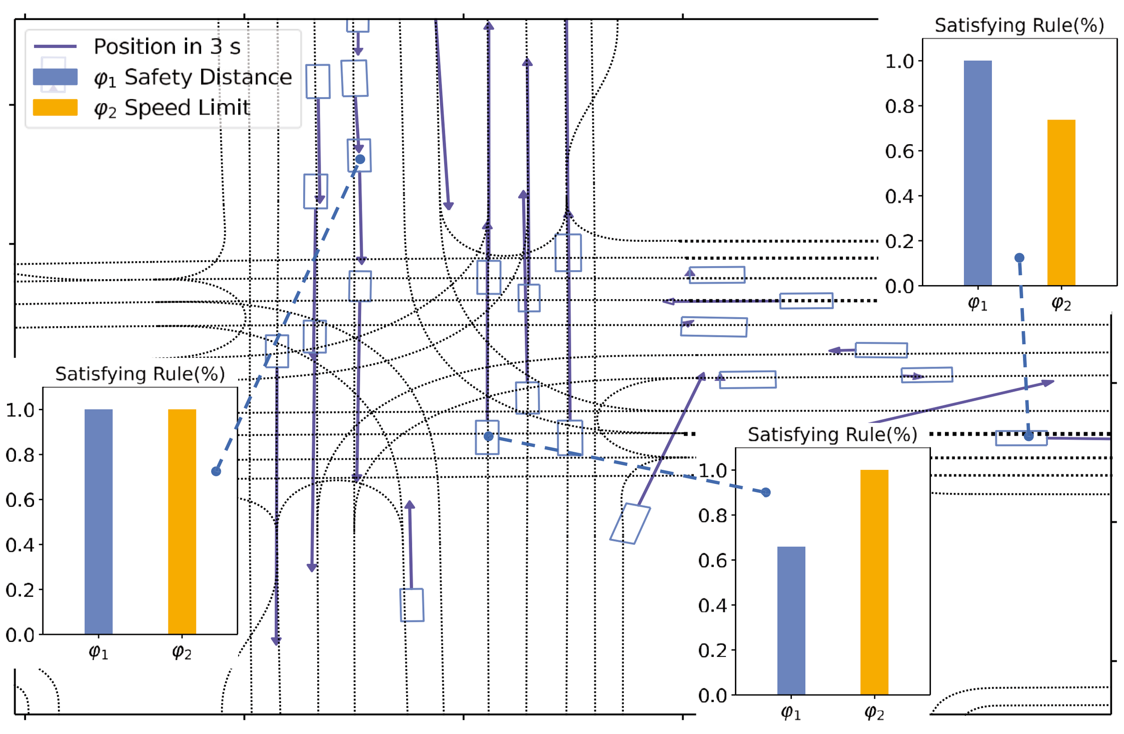

Figure 1: Scene from the Waymo Open Motion Dataset, where the rule adherence of each actor was analyzed and visualized for selected ones. The analyzed rules are safety distance (φ_1) and speed limit (φ_2).

We analyzed a set of two rules. Using the „three second rule", we first analyzed whether traffic participants violate necessary safety distances. Second, we analyzed how well traffic participants follow speed limits.

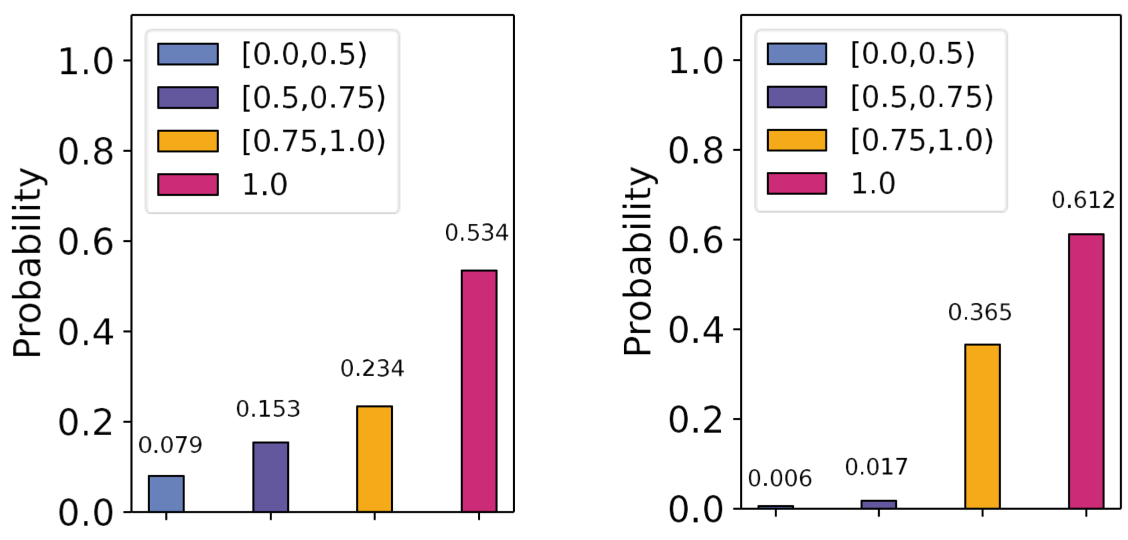

Figure 2: Analysis of traffic road user behavior regarding the traffic rules safety distance (left) and speed limit (right).

We learned that drivers follow speed limits rather strictly, while their behavior regarding safety distances is more flexible. Based on these insights we designed the action space for our knowledge integration experiments.

Informed Reinforcement Learning for Situation-Aware Traffic Rule Exceptions

For the integration of knowledge into a neural network we chose Reinforcement Learning as our training paradigm. As we were interested in whether knowledge integration can improve an agent's performance, we chose DreamerV3 [4] as our baseline and analyzed scenarios where controlled rule exceptions were necessary. In our work, we introduced a reward design that features a hierarchical rule-book [5] to enable situation-aware behavior [2].

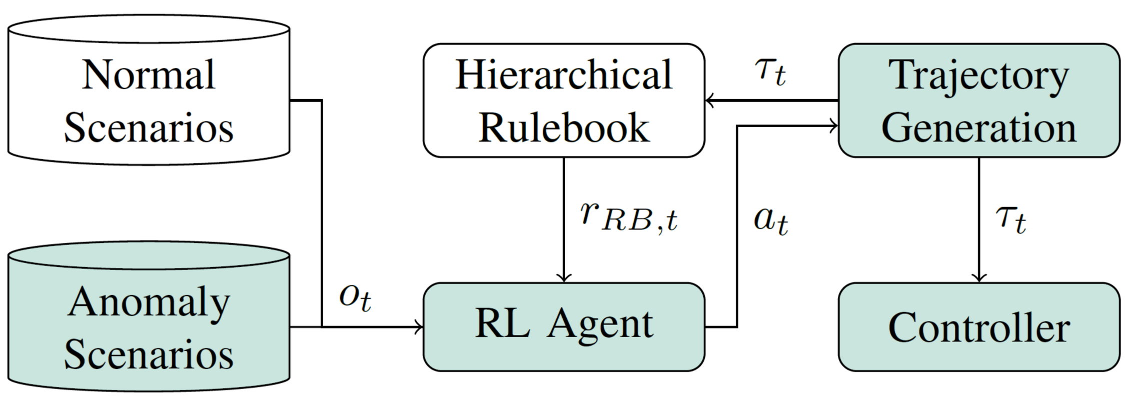

Figure 3: We use Curriculum Learning, where normal scenarios are used first to learn basic driving behavior. Then, anomalies are introduced to learn controlled rule exceptions.

During training, our agent was given knowledge about blocked lanes and the rule exception that the oncoming lane can then be used. During inference, our agent navigate such scenarios only based on observations.

Figure 4: Situation-aware usage of the oncoming lane in cases where a road blockage allows to do so.

In order to integrate physical constraints, we provided the agent with an action space that only produces valid trajectories. Our agent can only follow valid trajectories. Combining our rulebook with trajectories leads to superior performance compared to all other baselines.

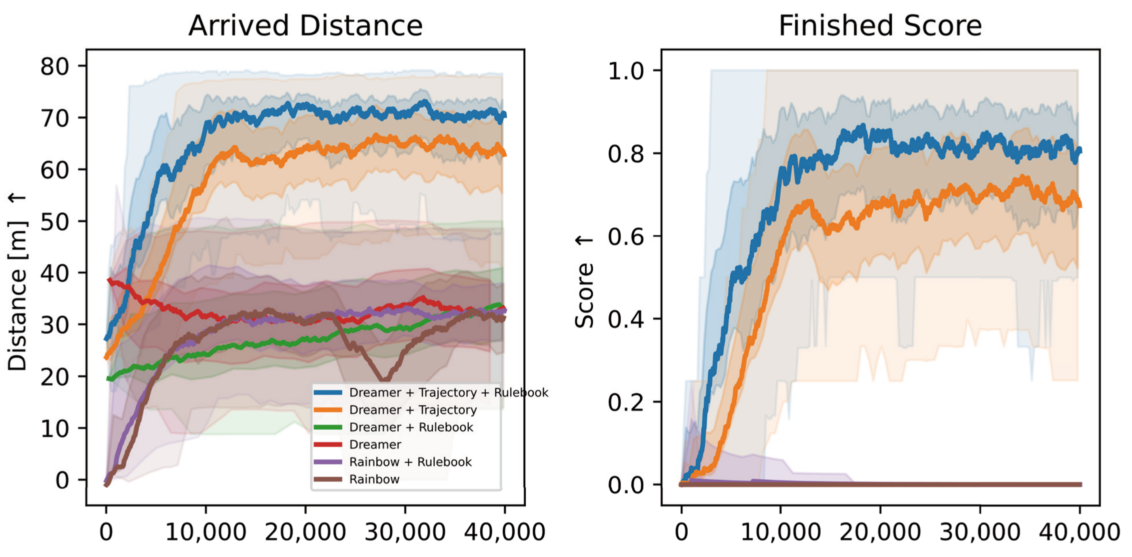

Figure 4: Situation-aware usage of the oncoming lane in cases where a road blockage allows to do so.

References

[1] Bogdoll et al.: Quantification of Actual Road User Behavior on the Basis of Given Traffic Rules, Intelligent Vehicles Symposium (IV), 2022
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