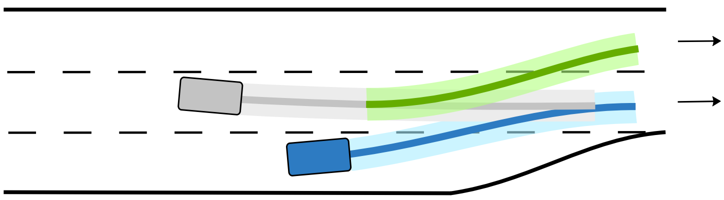
Efficient Trajectory Repairing for Autonomous Vehicles Regarding Traffic Rule Violations

Background

Autonomous vehicles need to comply with traffic rules so that they cannot be held liable for traffic accidents. However, most motion planning algorithms [1] do not explicitly consider traffic rules that are formalized in a precise and mathematical way. Once traffic rule violations of an initially-planned trajectory are detected by our previously-published traffic rule monitor [2], replanning the complete trajectory would be inefficient. To solve this problem, one solution is to deform or repair the invalid trajectory based on the violated traffic rules, which we call trajectory repairing. We address exactly this problem for which a satisfying solution does not yet exist in the literature.

Description

The aim of this thesis is to devise a trajectory repairing algorithm for autonomous vehicles, which explicitly takes different traffic rule violations into consideration. As a first step, the formalization of traffic rules [2] and their quantitative evaluation in Single Temporal Logic (STL) [3] should be investigated (see [4] for a survey on motion planning with temporal-logic specifications). Afterward, the differentiable *robustness value* of the predicates needs to be defined, e.g., in the curvilinear coordinate system [5], which describes the degrees (real numbers) of satisfaction or violation with respect to formulas [3, 6]. Based on the derivatives of the robustness value, we can compute the time-to-violation (TTV) and the time-to-compliance (TTCC), which denote the time that remains until the traffic rule violations and the maximum remaining time to execute the last possible maneuver to comply with traffic rules, respectively. Following that, efficient optimization methods can be developed to optimally repair trajectories, such as by maximizing the robustness value using convex optimization technologies [7, 8]. In order to ensure computational efficiency, the approach should be anytime-capable [9]. Moreover, the results should be demonstrated in CommonRoad[1] [10], which is a collection of composable benchmarks for motion planning on roads.



The planned trajectory of the ego vehicle (gray) violates the traffic rule *R_I5* [2], since it does not consider the entering vehicle (blue). Therefore, the ego vehicle's trajectory needs to be repaired to prevent the traffic rule violation (green).

[1] https://commonroad.in.tum.de/

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Research project:
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Type:
Master's Thesis

Research area:
Temporal Logic, Motion Planning, Traffic Rules

Programming language:
Mostly Python, could involve some C++

Required skills:
Advancded programming skill, able to work independently, familiar with motion planning algorithms and cyber-physical systems

Language:
English

Date of submission:
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Tasks

- Literature review of works related to trajectory repairing and motion planning with temporal logic specifications
- Formalizing the traffic rules in STL and defining differentiable robustness value of traffic rule satisfaction
- Implementing different methods to find appropriate sections of initially-planned trajectories to be repaired
- Deriving safety constraints for the repairer, e.g., collision avoidance [11]
- Developing different optimization methods to optimally repair trajectories regarding traffic rule violations
- Evaluation of the developed approach on CommonRoad scenarios
- Documentation of codes and other related materials

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