Satisfiability-based Trajectory Repairing for Autonomous Vehicles

Background

Autonomous vehicles need to comply with traffic rules so that they cannot be held liable for traffic accidents. To formalize the traffic rules in a precise and machine-readable manner, temporal logic languages are often used, such as Linear temporal logic (LTL) [1, 2], metric temporal logic (MTL) [3], and signal temporal logic (STL) [4].

Screenshot of a scary Tesla FSD video[1].

Description

If autonomous vehicles always comply with traffic rules, they cannot be held liable for a collision. However, it is computationally nontrivial to ensure the compliance of real-time motion planning with all traffic rule constraints, especially in complex situations. Obviously, if planned trajectories are not rule-compliant or physically infeasible, one can replan them for consecutive planning cycles. Nonetheless, replanning a complete trajectory is often unnecessary and time-consuming. To solve this issue, one interesting approach is the trajectory repairing framework proposed in our previous work [5]. The concept in [5] only considers scenarios with collisions, but does not repair trajectories violating traffic rules formalized in temporal logic. We plan to use satisfiability checking techniques to address the latter problem, which have been successful in tackling system verification and combinatorial search problems, e.g., satisfiability modulo theories (SMT) [6]. The results should be demonstrated in CommonRoad[2] [7], which is a collection of composable benchmarks for motion planning on roads.

Tasks

- Literature review of works related to traffic rule formalization, satisfiability checking technologies, motion planning with temporal logic specifications
- Familiarizing with the current trajectory repairing framework and the existing traffic rule monitor in CommonRoad platform
- Defining/Including traffic rules starting with the future temporal operator
- Implementation of handy rule predicate robustness evaluations similarly as [8]
- Integration of the mixed-integer linear programming [9] into the trajectory repairing framwork
- Evaluation of the developed approach on CommonRoad scenarios
- Documentation of codes and other related materials

[1] https://www.youtube.com/watch?v=j2I82tbiVHQ&t=215s
[2] https://commonroad.in.tum.de/

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Research project:
-

Type:
MA

Research area:
Motion Planning, Traffic Rules, Satisfiability Checking

Programming language:
Python

Required skills:
Advanced programming skill, able to work independently, familiar with motion planning algorithms

Language:
English

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