Efficient Falsification of Motion Planners for Autonomous Vehicles Using Rapidly-Exploring Random Trees

Verification of motion planners is often performed by testing the software with predefined test cases. These test cases usually cannot evaluate every corner case, since many corner cases are not known during development. In contrast, formal methods guarantee safety with respect to a specification, but the motion planner can still have implementation mistakes. Therefore, a general test approach is necessary which is able to test all possible operating scenarios of a vehicle and which works efficiently.

One possible test approach is falsification [1]. Falsification tries to disprove the safety of a system instead of proving it. In our previous work [2], we developed a concept for the falsification of Adaptive Cruise Control (ACC) systems [3]. The falsification system acts as leading vehicle and the ACC vehicle tries to follow this vehicle by keeping a safe distance (cf. figure below). If the ACC vehicle violates safety, the leading vehicle can apply full braking and it will come to a collision. We use a forward and a backward simulation approach to efficiently falsify state-of-the-art ACC systems. The forward simulation starts in safe states and tries to find unsafe states and the backward simulation starts in unsafe states and tries to find safe states.

To follow a leading vehicle, ACC systems adjust the velocity of the ACC-equipped vehicle so that the headway \( \Delta s = s_{\text{lead}} - s_{\text{acc}} \) is larger than a safe distance \( s_{\text{safe}} \).

Description

The aim of this thesis is to extend the approach introduced in [2] to arbitrary road networks using our framework CommonRoad [4]. The approach uses Rapidly-Exploring Random Trees (RRTs) [5] to simulate the behavior of the leading vehicle. However, this system currently works only in longitudinal direction. Therefore, the system should be extended for lateral movements by considering our existing forward and backward strategies. Additionally, different sampling strategies for the RRT should be evaluated in order to efficiently falsify motion planners. To improve the computational performance of the approach, the falsification should be parallelized.

Tasks

- Familiarizing with falsification approaches for motion planners
- Familiarizing with RRTs and our existing falsification system
- Extend the existing approach to arbitrary road networks
- Develop different sampling strategies
- Implement a parallelization strategy
- Falsify a provided motion planner
- Compare the implemented sampling strategies
- Compare the RRT-based falsification with Monte Carlo simulation

For more information please contact us:

Phone: +49.89.289.18131
E-Mail: sebastian.maierhofer@tum.de
Internet: www6.in.tum.de/people/sebastian-maierhofer-msc
References


