BA/SA: Evaluating Trajectories with Criticality Measures and Robustness Metrics for Autonomous Driving

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Background

Autonomous driving (AD) has seen a spike of interest in recent years with increasing focus on its safety. One essential part is the testing and possible falsification of planning algorithms in critical scenarios. However, those critical scenarios only rarely occur in real-word datasets but are essential for safety assessment [1]. To tackle this problem, our chair is currently developing a software for automatically increasing the criticality of interactive scenarios as part of the EU-Horizon project i4Driving [2]. The long-term goal of i4Driving is to lay foundation to a driver license for autonomous vehicles ("KI-TÜV"). We furthermore aim to use the software to test our own planners for the TUM autonomous research vehicle EDGAR.

Figure 1: TUM Research Vehicle EDGAR

Description

Our approach analyses the reachable sets of the traffic participants, limits them to achieve traffic rule compliance [3] and predictively finds an attacking point. Afterward, a relaxed QP-Problem is solved to plan the trajectories. Finally, the VUT plans its trajectory and possible collisions are detected.

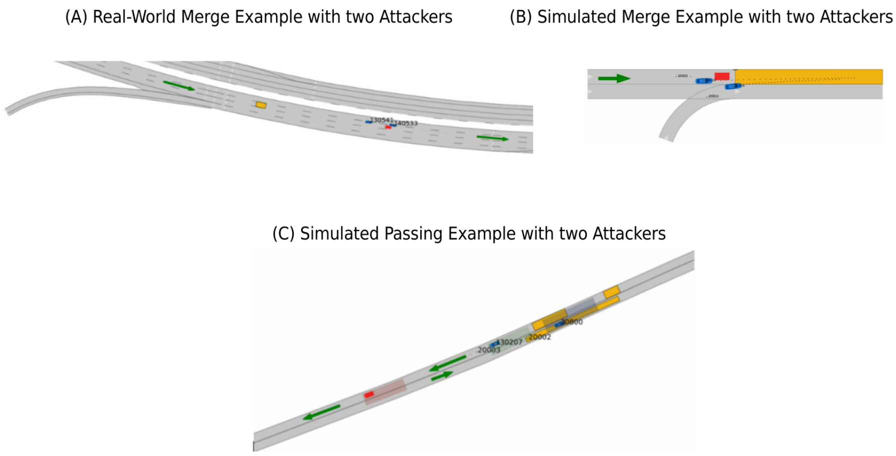

Figure 2: Exemplary Results of our Software. The VUT (red) is attacked by attackers (blue) using their reachable sets (translucent polygons).

Although the current software has produced promising first results, there are a number of open

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Research project:
i4Driving, CommonRoad

Type:
BA/SA

Research area:
Autonomous Driving - Planning and Falsification

Programming language:
Python

Required skills:
Python, OOP, Git

Language:
English, German

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research topics to it. One of these topics is the incorporation of an evaluation of the VUT trajectory via state-of-the-art safety metrics.

In recent years, evaluating the safety in autonomous driving has become increasingly popular. Two widely used methods to quantify safety are criticality measures and robustness metrics. Very generally speaking, criticality measures assign a quantifiable value to some behavior of an autonomous system. For example, the time-to-collision gives a real-valued time value for the critical situation of a possible collision [4]. On the other hand, robustness measures assign a value to how well a system complies with a defined rule, with a negative value usually implying a violation. For example, the robustness metric of keeping the speed limit could be defined as the difference between the the speed limit and the longitudinal velocity [5]. Criticality measures involve, for example, time, velocity, distance and drivable area [4] whereas robustness metrics may include values based on the current state variable values of the vehicle or Signal Temporal Logic [5, 6].

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Tasks

This thesis focuses on investigating, evaluating and integrating existing criticality measures and robustness metrics from the literature into our framework for the described trajectory evaluation and defining an overall metric for evaluating the VUT trajectory.

As we are in an early stage, we currently focus on simulated and real-world highway merge and passing scenarios only, specified in our own CommonRoad format [7, 8], which is used in several national and EU-wide projects. We, furthermore, recommend having intermediate skills in dealing with research code, although we can provide assistance.

Your tasks are:

1. Investigating current approaches in the literature
2. Evaluating the feasibility of incorporating them into our approach
3. Implementing them in an OOP, well documented, fashion
4. Defining an overall evaluation metric or method for the VUT trajectory based on the incorporated findings
5. Making your solution work with the currently used code

Application

If you are interested in the topic, please send an email to the contact information provided on the right and attach a short **CV**, your current **grade report** and your **bachelor grade report**.

If you have extra-curricular projects or a student job, please attach information about it.

References

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