MA/SA: Development of a Negotiation Algorithm for Multi-Agent Driving in the Context of Falsification

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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-world 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 the foundation for a driver license for autonomous vehicles ("KI-TÜV"). We furthermore aim to use the software to test our planners for the TUM autonomous research vehicle EDGAR.

Figure 1: TUM Research Vehicle EDGAR.

Description

Our falsification is currently facilitated via set-based predictive [3] multi-agent driving, in which our software takes control over other traffic participants (attackers) and aims to simultaneously let them perform maneuvers that produce critical situations for the Vehicle-under-Test (VUT) whilst also still following their own goals. This approach is motivated by the fact that critical scenarios in the real-world are seldom caused by malicious intend, but rather by unthoughtful behavior of individuals pursuing their own goals.

Our approach analyses the reachable sets of the traffic participants, limits them to achieve traffic rule compliance [4], and heuristically finds a predictive attacking point. Afterward, a QP optimization problem is solved to plan the trajectories. Finally, the VUT plans its trajectory and possible collisions are detected.

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Research project:
i4Driving, CommonRoad

Type:
MA/SA

Research area:
Autonomous Driving - Planning and Falsification

Programming language:
Python

Required skills:
Python, OOP, Git

Language:
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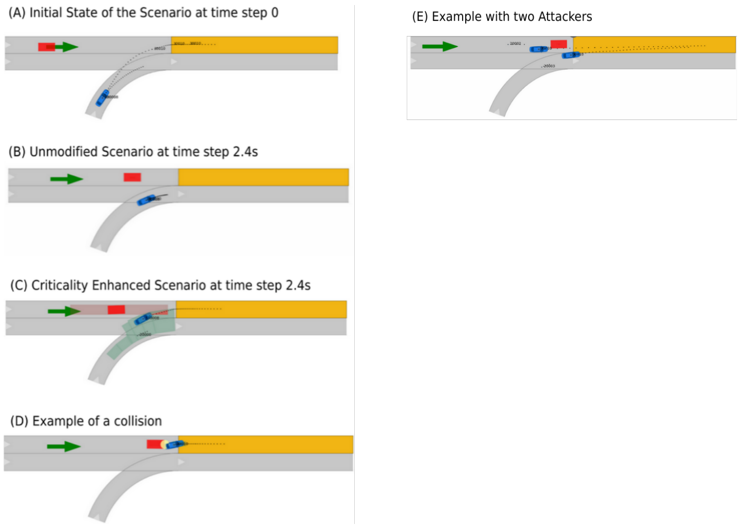

Figure 2: Exemplary Results of our Software. The VUT (red) is attacked by attackers (blue) using their reachable sets (translucent polygons).

Although the current software has given promising first results, there remains a number of open research topics to it. One of these topics is that the attackers currently might collide with each other. The central goal of this thesis is to improve our existing software by developing new, robust algorithms for the existing software that negotiate the driving between the attackers.

Conflict resolution in multi-agent driving is an increasingly investigated field of AD [5]. In our case, possible solutions could be classified roughly in two categories: One can either use the un-negotiated drivable areas and perform multi-agent planning in them or negotiate the reachable sets themselves and perform single-agent planning in them. Existing approaches for negotiating the reachable sets themselves include centroid clustering [6] and game theory [7] whereas multi-agent planning can, for example, be achieved via multi-agent MPC [8, 5] or multi-agent reinforcement learning [9].

In the case of falsification, we aim to extend the existing research by developing an algorithm that can both resolve the conflict between different attackers whilst simultaneously still allowing critical situations to happen with respect to the VUT.

Tasks

This thesis focuses on developing and integrating new algorithms (from the literature, maybe with your own spin on them and own ideas) for the described negotiation of the attacking vehicles with the requirement of still increasing criticality.

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 [10, 11], 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, most likely MPC-based
2. Developing one or more approaches based on our requirements
3. Implementing the approaches in an OOP, well documented, fashion
4. Evaluate the implemented strategies
5. Making your solution work with the currently used code

Application

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

If you have extracurricular projects or a student job, please attach information about it.

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