Cluster C

Planning, Decision-making and Safety

C1 - Scenario trajectory parameterization

Scenario-based testing has been proposed for improving the efficiency of the Verification and Validation (V&V) of Automated Driving Systems (ADSs) and Advanced Driver Assistance Systems (ADASs).

In this project we want to explore and evaluate different parameterization approaches to cut-in trajectories, including Bezier and different types of polynomial fitting.

In this master thesis project, you will focus on:

- Analyzing lane change and cut-in trajectories data from naturalistic driving scenarios
- Implementing a Bezier curve fitting algorithm to parameterize the trajectories
- Explore additional curve fitting approaches, suitable for statistical modeling and scenario-based testing
- Define comparison metrics and evaluate the different parameterization approaches
- Implement curve-generation methods based on the parameterized trajectories in suitable simulation environment(s)
- Define comparison metrics and evaluate the parameterization approaches in simulation environments to understand their respective advantages and disadvantages

C2 - Adaptive Stress Testing of Safety-Critical Automotive Software using Adversarial Reinforcement Learning

As the automotive industry is moving to continuous deployment of complex software, it becomes important to find issues quickly to allow for frequent updates of the implementation.

In this thesis, we want to evaluate adaptive stress testing to understand if it can be used to speed up the process of finding issues in a safety-critical software component. Adaptive stress testing aim to generate scenarios to test the system against, which falsifies the requirements. Some examples of how this can be done is logic-based search optimization, reinforcement learning, subset simulation, generative agents, or accident databases.

In this project you will focus on:

- Using a closed-loop simulation environment to simulate interactions between vehicles
- Applying reinforcement learning for scenario generation
- Investigating diversity-oriented adaptive stress testing (e.g., trajectory diversity, coverage metrics)
- Evaluating generated scenarios
- Investigating scalability in terms of realism and transferability to more complex traffic scenarios

C3 - Reasoning / QA Training of VLA Models for Parking

The thesis investigates how to specialize the reasoning / QA part of a VLA model so that it captures parking-specific causality, and what data and training procedure are required to do so.

In this master thesis project, you will focus on:

- Surveying reasoning components in current driving VLAs
- Building a parking Chain-of-Causation / QA dataset on top of existing parking repos
- Training the reasoning / QA component of a released VLA on the parking dataset
- Defining an evaluation framework for parking reasoning quality and reasoning–action alignment

C4 - Object-level Trajectory Planning Using World Models

Planning trajectories in dynamic driving scenes requires predictions of how the scene will evolve over time. The trajectory planned by the ego vehicle can, to some extent, influence the decisions made by other agents in the scene, and should ideally be taken into account when predicting the scene's evolution.

Recently, world models have demonstrated strong performance on this task. By learning directly in a latent space, they are able to make accurate predictions of how a driving scene will unfold conditioned on the actions planned by the ego vehicle. Most world models used for autonomous driving scene prediction operate directly on sensor data, but a similar approach could in principle be developed using object-level data like road model elements or past agents' trajectory points.

In this master thesis project, you will focus on:

- Choosing a suitable world model architecture by browsing the AD motion prediction literature.
- Training an object-level world model on open source datasets
- Training a reinforcement learning agent for planning trajectories for the ego vehicle.
- Benchmarking performance and speed against baselines

C5 - Virtual Verification First for E2E AD software development framework

Virtual verification is widely used to generate synthetic data for testing AD software. With the classic Perception-Planning-Action, object level output of the perception lay can serve as perfect KPIs for evaluating the fidelity of environment and sensor models in the simulator. As AD software moves to E2E architectures, however, new approaches on sensor output are needed.

In this master thesis project, you will focus on conducting a series of experiments to study the mixing rate with different models, from YOLO (small models) to VLA (large models), and explore the use of synthetic data and real data for verification and simulation aspects.

C6 - Clustering methods for cut-in scenarios

Establishing feature performance with statistical confidence across the ODD of cut-in scenarios requires evaluation over a broad and representative set of traffic situations. Scenario mining (or fleet insight) data provide substantial coverage of real-world cut-in behavior, but the number of recorded events exceed what can practically be simulated on a frequent basis.

Clustering approaches provides a data-driven approach for organizing cut-in events into groups with similar characteristics. Statistical machine/deep learning clustering methods can identify underlying structure in the data without requiring predefined cut-in categories.

In this master thesis project, you will focus on:

- Exploring and analyzing large sets of recorded cut-in events, including vehicle trajectories, scenario metadata, and sensor feeds.
- Designing and implementing methods to represent cut-in scenarios, for example using trajectory parameterizations, similarity metrics, or learned representations from raw data.
- Studying how different clustering approaches, applied to your representations, capture variation in cut-in behavior, and evaluating their ability to produce meaningful and well-separated scenario groups.
- Investigating how clustered scenario sets can be used for stratified sampling and efficient simulation-based evaluation of feature performance across the cut-in ODD.

C7 - Evaluation of predictors for safety assessment

Advanced Driver Assistance Systems (ADAS) are increasingly integral to modern vehicles, offering features such as lane keeping, adaptive cruise control, and automated emergency braking. These systems rely on a combination of sensors, perception algorithms, and control logic to support safer and more comfortable driving. As ADAS technologies advance toward higher levels of automation, ensuring their safety in real-world conditions becomes a critical challenge.

To validate specific safety and performance requirements, there is a need to analyze metrics and predictors that lie closer to the functionality of the system. This project aims to investigate such metrics, determine their respective correlation to the risk of a given action by the system as well as understanding how much data is needed to make valuable and valid extrapolations/predictions.

In this master thesis project, you will focus on:

- Applying state-of-the-art statistical methods on large data sets to evaluate different safety predictors
- Explore different metrics for estimating system safety
- Validating the use of safety predictors to estimate real-life traffic safety

C8 - Neural controller for parking scenarios

Automated parking systems typically rely on a combination of environment perception, trajectory planning, and low-level vehicle control. A key challenge is that perception of parking boundaries, free space, and nearby obstacles can vary between consecutive frames. This can lead to instability or inconsistency for planning purposes, especially during precise low-speed maneuvers.

The proposed project aims to investigate a temporally aware neural parking able to generate robust parking behavior. The project may consider both trajectory-based neural planning with conventional control and a more fully end-to-end formulation where the neural policy directly predicts vehicle commands.

In this master thesis project, you will focus on:

- Conduct literature study on available reconstruction techniques.
- Explore and develop a neural parking controller, establish an evaluation benchmark, and assess the strengths, limitations, and trade-offs of the proposed approach.
- Test your solution
- Document your findings, approaches and potential improvements

C9 - Evaluation of Search-Based Falsification Methods for Safety-Critical Driving Software

The verification and validation of Advanced Driver Assistance Systems (ADAS) and Automated Driving Systems (ADS) is challenging due to the enormous number of possible traffic situations that may be encountered during operation.

To address this challenge, researchers increasingly rely on falsification methods, which aim to automatically discover scenarios that cause a system under test to violate a safety requirement.

The objective of this thesis is to investigate and compare different search methods for falsification of a software component responsible for driving decisions in a simulated traffic environment.

In this master thesis project, you will:

- implement and evaluate different search methodologies
- evaluate them using a common set of driving scenarios and safety requirements.
- assess performance using quantitative metrics