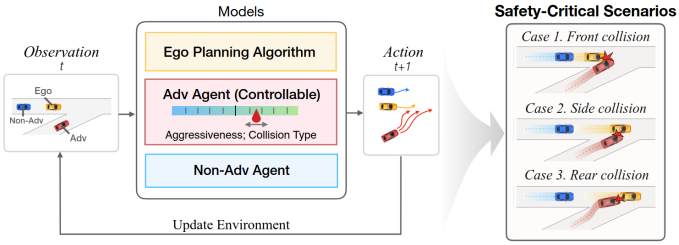
Karlsruhe Institute of Technology

Master Thesis



Example framework which controls a diffusion based planner with guidance functions[1]

Diffusion-Based Traffic Scenario Generation with Safety and Criticality Guidance

Modern autonomous driving systems are typically trained and evaluated on large-scale real-world datasets. However, rare, safety-critical traffic situations (so-called corner cases) are severely underrepresented in naturalistic driving data, limiting the robustness and reliability of learned planning and prediction models. Recent advances in diffusion-based generative models have demonstrated strong capabilities for multi-agent trajectory generation, but steering these models toward specific safety-relevant or adversarial scenarios remains an open research challenge.

This thesis focuses on guidance mechanisms for diffusion models that enable targeted generation of safe, unsafe, and safety-critical traffic scenarios. Guidance functions can encode geometric constraints, interaction-based metrics (e.g., time-to-collision, minimum distance), traffic rules, or adversarial objectives. The goal is to systematically design, implement, and evaluate such guidance terms to generate meaningful and diverse traffic scenarios for stress-testing autonomous driving systems.

The proposed thesis consists of the following parts:

+ Literature research about current diffusion based traffic simulation models
+ Study of safety and criticality metrics in autonomous driving (e.g., collision metrics, interaction measures, traffic rules)
+ Implementation of guidance mechanisms within a diffusion-based trajectory generation framework
+ Experimental evaluation of generated scenarios with respect to safety, realism, diversity, and controllability

What you will gain from this thesis:

+ Hands-on experience with state-of-the-art generative models
+ Opportunity to contribute to cutting-edge research in scenario generation and robustness with potential for top-tier publications.
+ Well-scoped thesis topic with room for independent research ideas

Please don't hestitate to contact me even if you don't meet all requirements. We can always find a way to adjust the scope of the thesis to your skills and interests. I am happy to answer any questions you might have. Feel free to ask for an appointment or directly ask at my office!

[1] Safe-Sim: https://arxiv.org/abs/2401.00391

Institute of Measurement and Control Systems (MRT)
Prof. Dr.-Ing. Christoph Stiller

Advisor:
Kevin Rösch, M.Sc.

Programming language[1]:
Python advanced

System, Framework(s):
Linux
Pytorch

Required skills:
- Knowledge in machine learning
- Work on your own

Language(s):
German, English

For more information please contact:

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Or directly send in your application including your current grades as well as our questionnaire!

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[1] **skill levels:**
Skill levels refer to the project scope, not your expertise in the respective language.

beginner	< 500 lines of code (LOC)
advanced	500 – 5000 LOC
proficient	> 5000 LOC