Scenario-based assessment of automated driving systems:

How (not) to parameterize scenarios?

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Paper

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Introduction

- United Nations Regulation 157 (UN R157) from 2021 for the approval of Automated Driving Systems (ADSs) states that "the activated system shall not cause any collisions that are reasonably foreseeable and preventable".
- UN R157 further proposes to use simulations of *parameterized scenarios* with human driver models to set a benchmark for ADSs.
- UN R157 provides three examples, without detailing on the particular parameters of the scenarios.
- *However, as shown in this work, the chosen parameterization has a significant influence on the result.*

Why parameterization?

- It enables testing beyond observed road scenarios.
- It facilitates statistical analysis of the system's performance.
- It allows to set bounds on what scenarios are reasonably foreseeable.
- It makes it possible to focus on scenarios where the ADS exhibits critical behavior.

Challenge

- Due to the "curse of dimensionality", statistical analysis and numerical computations are difficult if too many parameters are used.
- Too few parameters require too many assumptions.
- *How to justify the chosen set of scenario parameters?*

Approach

- Simulate scenarios by replaying observed scenarios.
- Repeat simulations while using the same scenarios in parameterized form.
- Compare the results, while looking at different performance indicators (because that matters).

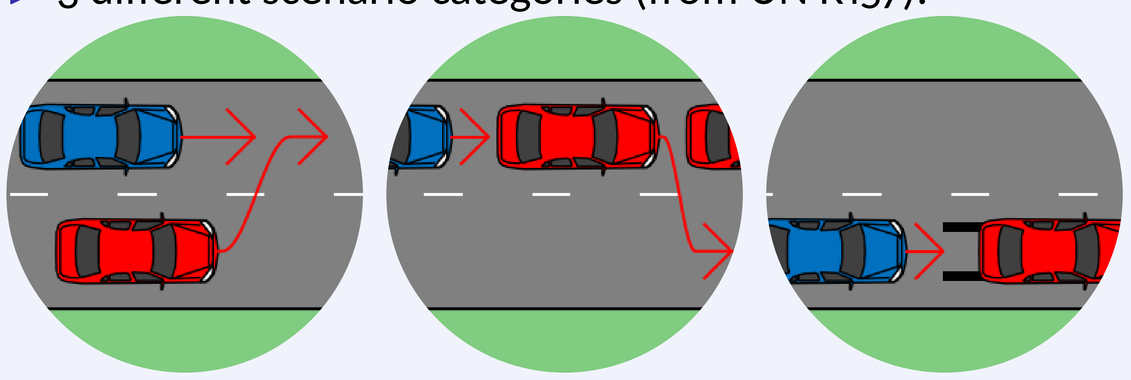
Case study

Conclusions

- *Parameterization matters!*
- The influence of the parameterization depends on, among others, the system under test and the specific metrics of interest.
- It is recommended that future amendments of UN R157 *require a justification of the chosen parameterization of scenarios*.

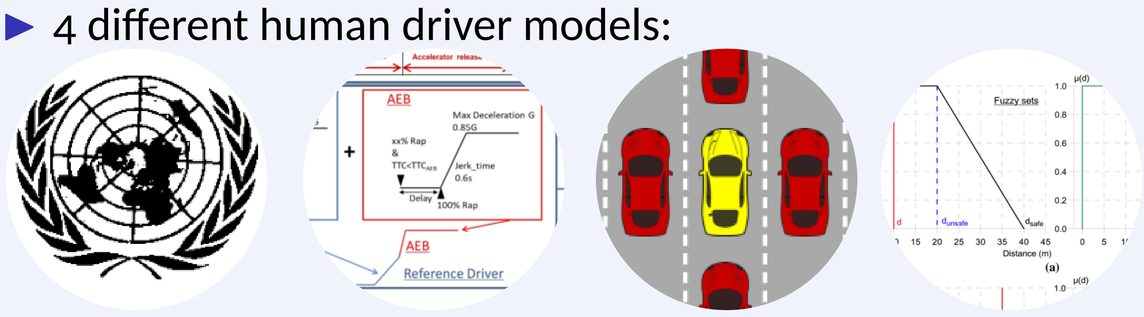
Setup case study

- 3 different scenario categories (from UN R157):



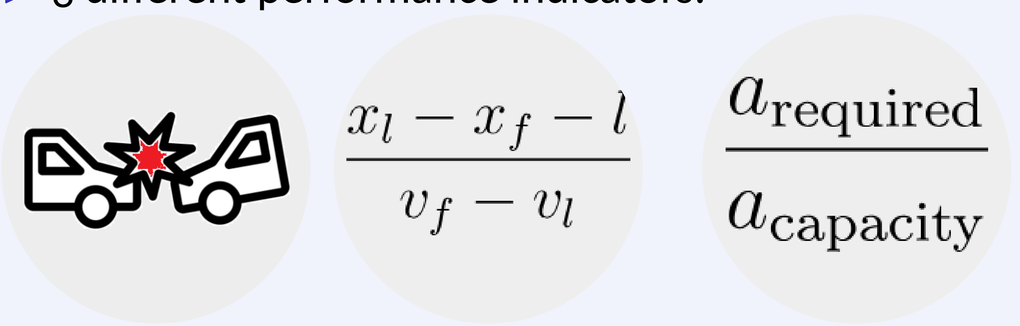
Cut-in *Cut-out* *Leading vehicle decelerating*

- Observed scenarios used from the HighD data set, with some changes to also have scenarios with collisions
- 5 to 7 different parameterizations per scenario category
- 4 different human driver models:



UN R157 model *Competent and careful human driver model* *Responsibility sensitive safety* *Fuzzy safety model*

- 3 different performance indicators:



$$\frac{x_l - x_f - l}{v_f - v_l} \qquad \frac{a_{\text{required}}}{a_{\text{capacity}}}$$

Collision *Time-to-collision* *Break threat number*

Results case study

- Alternative parameterizations perform better.
- Results depend on model.
- Results depend on performance indicator.
- See full paper for all figures.

Results cut-in

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