VERIFICATION
VALIDATION
METHODS

PROJECT of the PEGASUS FAMILY

ADVANCED SCENARIO SPACE EXPLORATION VIA SIMULATION

A Concept for Guarateeing Complete Criticality Identification

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Problem Statement

Given:

- A simulation model  of an ADS*)
- A logical test scenario 

Task:

- Perform a **comprehensive virtual test** of the ADS behavior in the given scenario
  - ➢ Find **all critical** concrete **instances** of the scenario

*) ADS: Automated Driving System

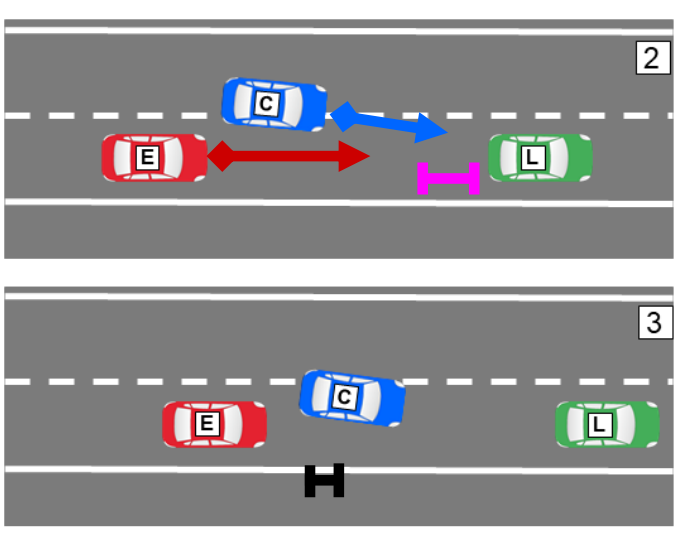


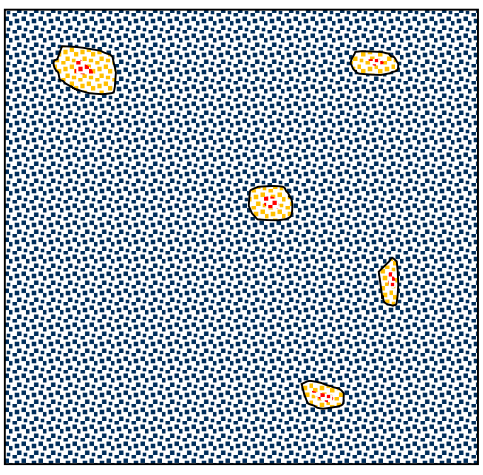
Illustration of a logical scenario

Two significant parameters:

gap size velocity difference

Problem Background:

- The ADS (the test object) may *not* be able to *avoid critical evolutions* for certain parameter combinations
- There may be *significantly* and *highly critical* concrete instances of the scenario
- It is *difficult* to cover the scenario space *completely* due to the high number of parameter combinations
  - ➢ *Even a thorough virtual test might overlook critical instances*



Criticality in a two-dimensional parameter space

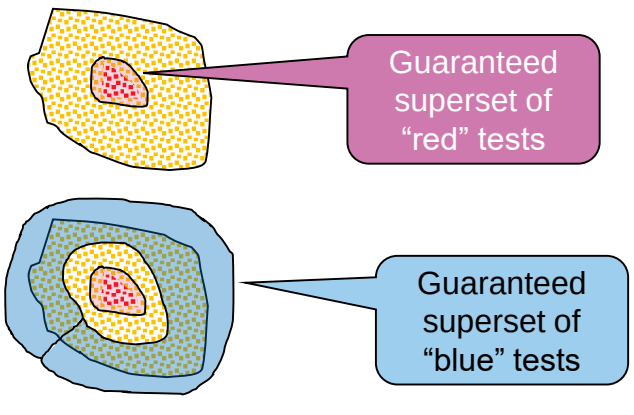
criticality *low*

criticality *significant*

criticality *high*

Technical Objective:

- Identify **all** parameter regions resulting in **highly critical** test runs
- This means to determine a (preferably small) **superset of highly critical** regions
- (Complemented by a superset of uncritical regions)



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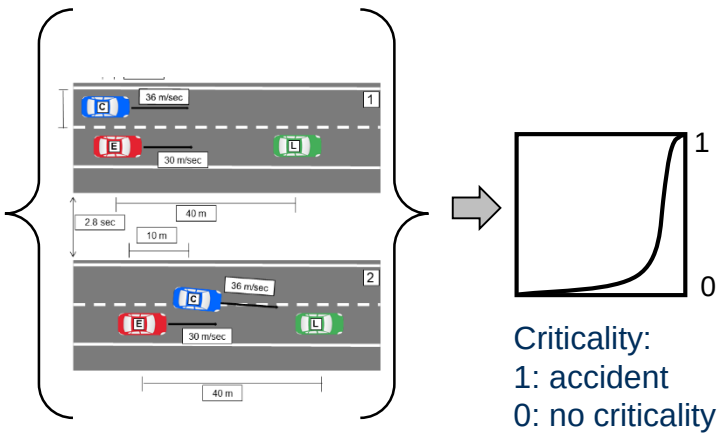
Solution Summary

1. Construct a Lipschitz-continuous indicator of criticality on trajectories
2. Identify parameter regions with continuous behavior
3. Cover each region Lipschitz-densely by witnesses
4. Construct criticality cover from witnesses

1. Criticality Indicator *CI*

- A function assigning a criticality value to each simulation run
- Lipschitz-continuous (limited criticality increase in local neighborhood)

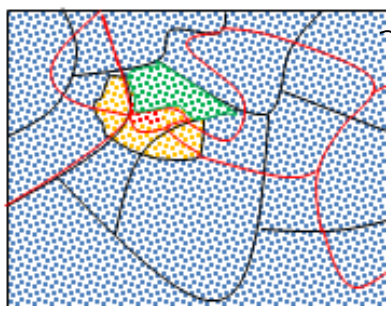


Simulation result

Criticality:
1: accident
0: no criticality

2. Identify continuous regions

- Parameter changes within these regions do not trigger discrete disruptions in behavior



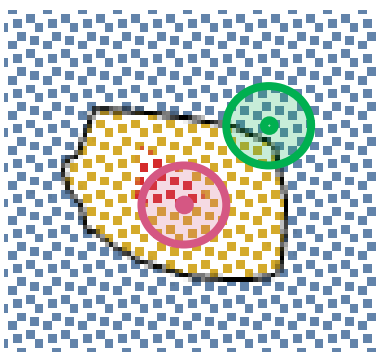
Discrete change of other vehicle (directly observable)

Discrete change of test ADS (to be detected via simulation)

Sample continuous region

3. Cover scenario space

- Compute **witnesses** by simulating concrete scenario instances
- Use Lipschitz-constant to determine **neighborhoods** of guaranteed **limited criticality range**
- Compute witness **neighborhoods** to **cover** each region



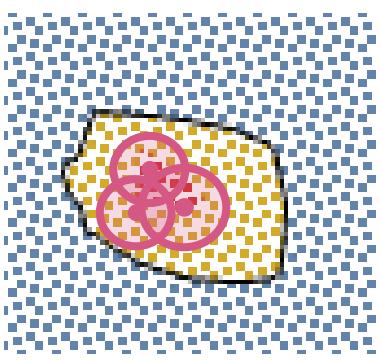
Criticality low

Criticality high

Witness neighborhoods

4. Construct criticality cover

- Combine **critical neighborhoods** to cover all critical scenario instances



Critical region cover

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Summary

- Approach to reliably identify all critical instances in large scenario spaces by simulation
- Addresses the problem of providing guarantees needed in safety argumentations

Status and Plans

- This work has been conducted in SET Level
- The concept is currently being elaborated
- A prototype implementation is planned
- Experiments are going to be conducted in VVM

SET Level

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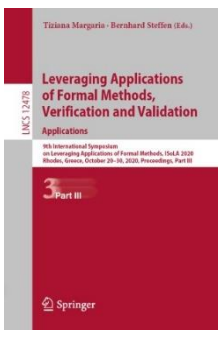
Reference Paper

Hungar, Hardi

A Concept of Scenario Space Exploration with Criticality Coverage Guarantees

Proc. ISoLA 2020, Springer LNCS 12478, pp. 293-306

DOI:10.1007/978-3-030-61467-6_19



https://link.springer.com/book/10.1007/978-3-030-61467-6

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