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BASICS FOR TESTING – Booth No. 17

TEST AUTOMATION, TEST-CASE GENERATION & CONTRIBUTION TO THE SAFETY ARGUMENT

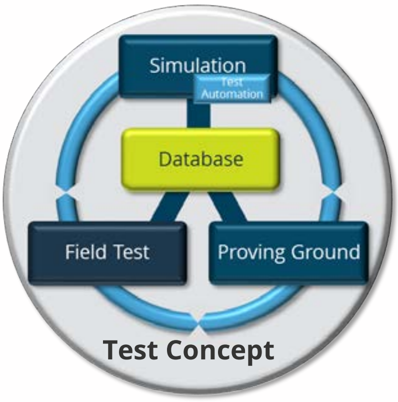
PEGASUS

PEGASUS Method for Assessment of Highly Automated Driving Functions

The objective of PEGASUS testing was to develop the PEGASUS method regarding completeness, correctness and consistency.

The simulation-based assessment of a large number of concrete scenarios contributes to the safety assessment of the vehicle functions for logical scenarios.
The test automation is the central element that enables this.

Test automation is part of the simulation framework.



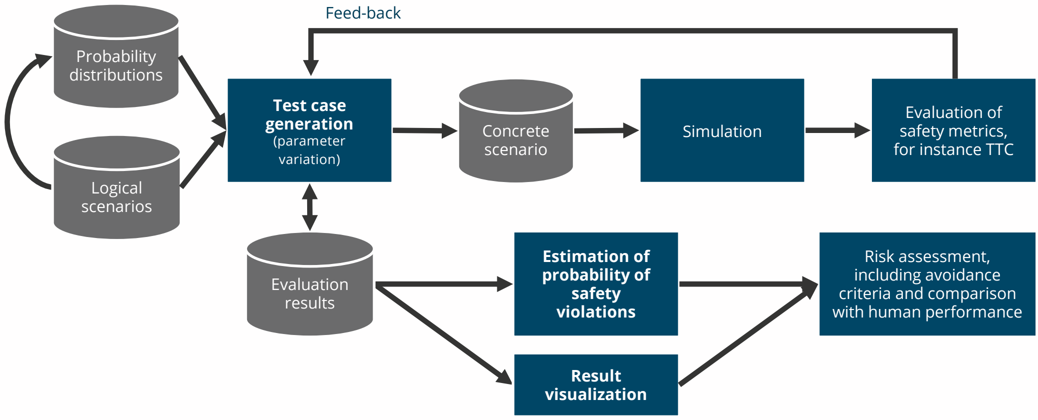
Above: Test-automation toolchain

Simulation

Goal: Testing of all scenarios from the data base (scanning the parameter space for identification of scenarios with risk of collision)
Input: Scenarios, parameters, pass criteria/metrics, ECO-SW-code as system under test
Output: Evaluated scenarios and the probability for collision scenarios

Test Automation

Goal: Based on stochastic variation within the parameter space of the logical scenario, concrete parameter sets are created automatically. The target is to execute a detailed search in the parameter space for critical parameter sets. A variance/probability-based robustness analysis is performed in parallel.
Input: Logical scenario and parameters (incl. distributions), pass criteria/metrics
Output: Concrete scenario (parameter set for logical scenario)



Above: Simulation-based assessment of vehicle functions for logical scenarios

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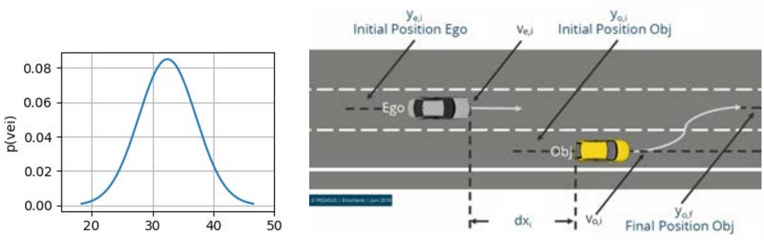
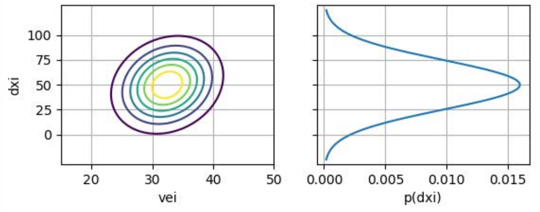
Objectives of simulation-based scenario assessment

Verification of the absence of safety violations in the most probable parameter subspace:

- Selection of subspace where no safety violations should occur (expert selections)
- Test case generation algorithms: increase the coverage & find worst-cases
- Expert evaluation of results
- Selection of worst-cases for proving ground tests

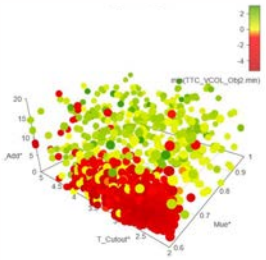




Logical scenario and normal probability distributions for two parameters. Experts can select regions for confirmatory safety verification.

Analysis of difficult real cases (e.g. accidents)

- Characterization of smaller subspace around seed scenario
- Expert evaluation of results

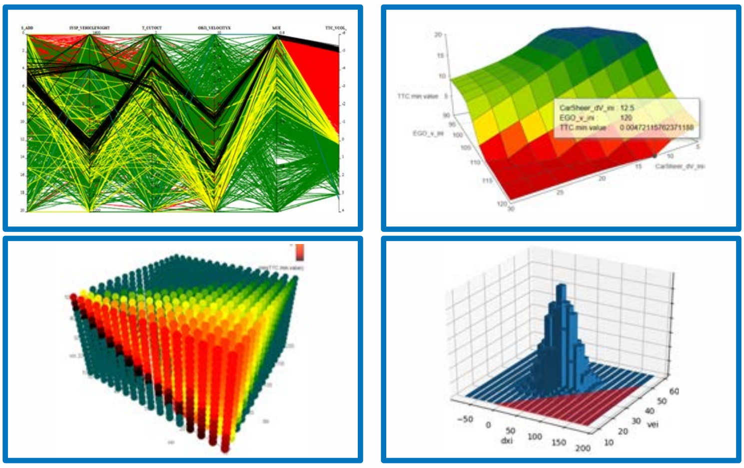


Characterization of the parameter space of logical scenarios:

- Identification of the regions with safety violations
- Identification of safety violation borders

Estimation of the probability for safety violations:

- Integration of probability of safety violation regions
- Expert assessment of results



Characterization of a parameter space and estimation of probability of safety violations

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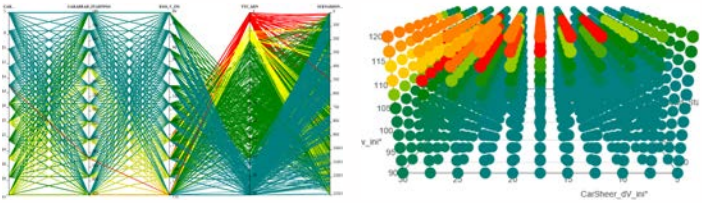
Algorithms for test case generation

Combine several strategies for a better characterization of the safety in the parameter space, for instance:

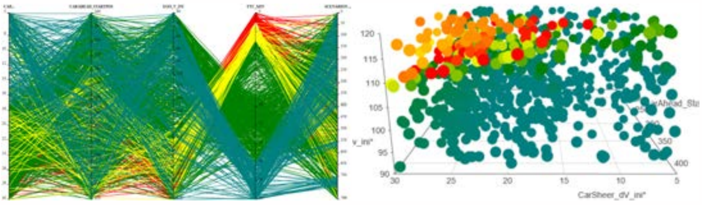
Increase the test coverage:
- Fixed sampling - combinatorial generation $C(N,K) * S^K$
- Random generation

Focus on safety violations and worst cases (optimization):
- Particle swarm
- Simulated annealing
- Local optimization

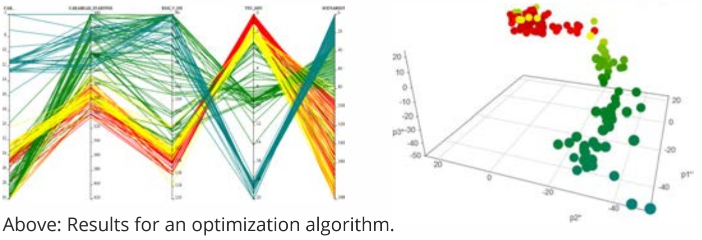
Identify the safety borders:
- Adaptive sampling, i.e. increase sampling rate around safety borders



Above: Results for fixed sampling with full Cartesian products.



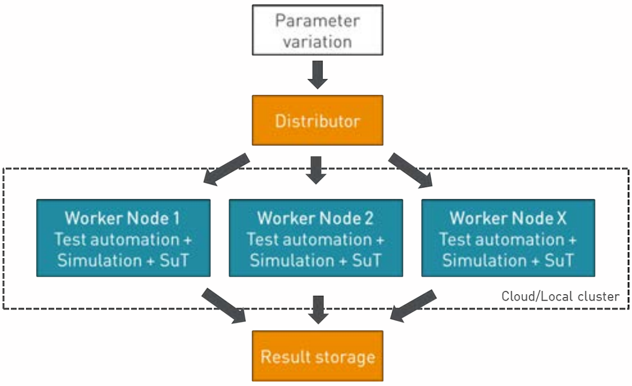
Above: Results for random generation.



Above: Results for an optimization algorithm.

Challenge: exponential complexity increase!

Strategies for effort reduction:
- Sensitivity analysis
- Learning of surrogate models
- Parallel computation on HPC platforms



Above: Parallel-computation approach for cluster and cloud.

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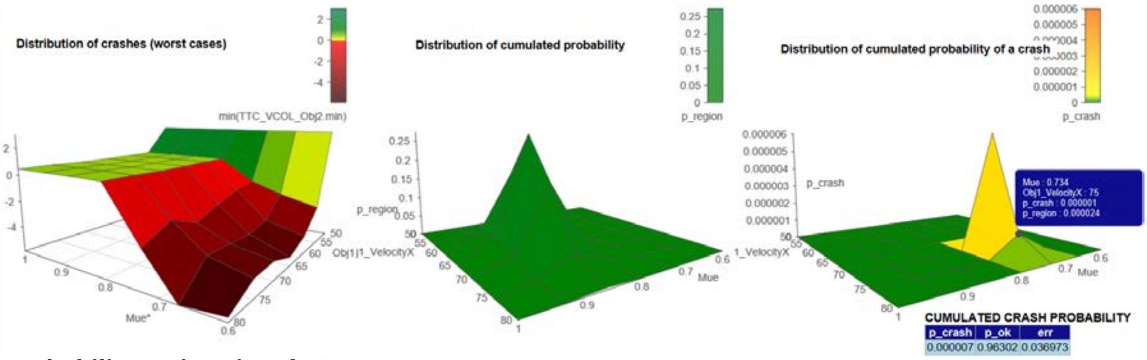
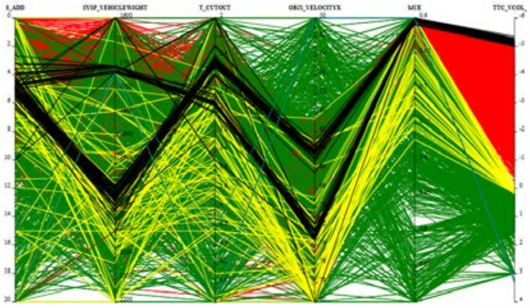
Estimation of probabilities and visualization of results

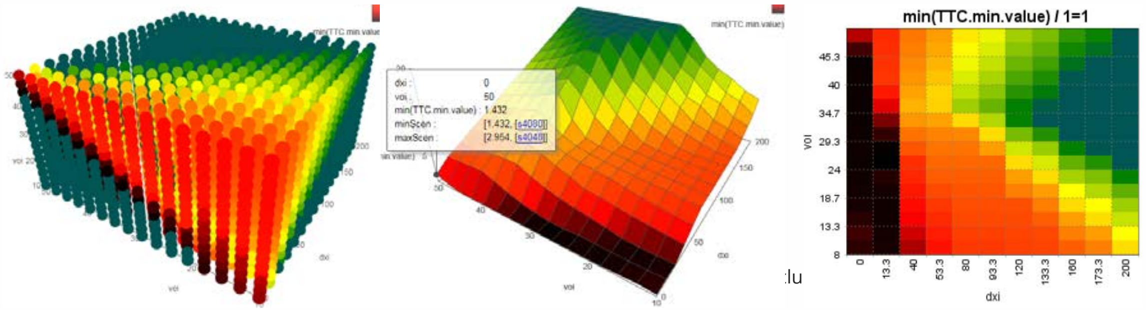


Probability estimation, for instance by integration of the prior probability in the regions with safety violations



Visualization of results with:

- ND parallel coordinates
- 3D scatterplots
- 3D surface plots
- 2D heatmaps



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