PROJECT of the PEGASUS FAMILY

VERIFICATION VALIDATION METHODS

V&V Domain – Application

14.5 | Empirical Simulation Validation

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Comparing Proving Ground and Simulation Data of an SAE Level 4 System

The goal of this activity was to evaluate the degree of realism in a detailed simulation for an automated vehicle and to develop and apply a method for evaluating the validity of the simulation results. This serves the purpose of tool qualification – required for any use of simulation tools in a safety-critical development.

Figure 1: Left turn scenario with driving SAE 4 automation on (top) proving ground and (bottom) within simulation (© Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR))

Approach

- Targeted experiments with an automated vehicle are performed on a proving ground.
- A model of the vehicle using the same automation function is run in simulation
- The recorded behavior of the other vehicles form the proving ground are replayed in the simulation
- The simulation outcome is compared with the reference data
- Discrepancies are analyzed and explained

Experiment Setup

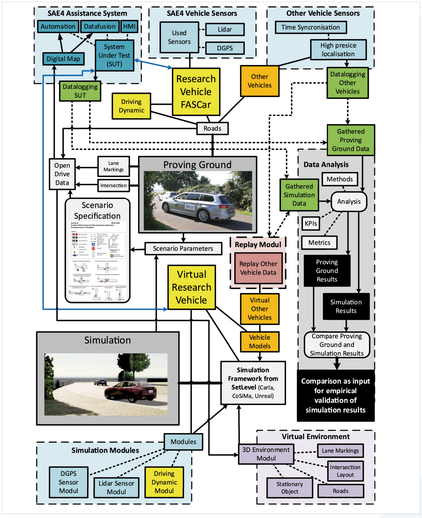
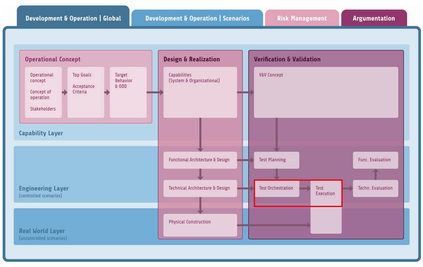


Figure 2: Components and dependencies of the experiment setup to compare and evaluate collected proving ground and simulation data (© Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR))



Senario Example

The following example shows a left turn scenario in which the automated vehicle must observe oncoming traffic.

Figure 3: Scenario – left turn introduced by colleded data on the proving ground, green line shows path of the SAE 4 automated vehicle, red line of the oncomming traffic (Data © Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR), Aerial map © City of Braunschweig, 2020)

Observations

- Discrepancies in position and timing are moderate
- Artefacts in perception in proving ground data
- Physic, dynamic and sensor models require proper calibration

Comparison and Results

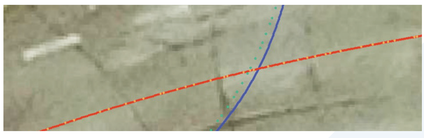


Figure 4: Detailed view on difference between proving ground (blue, red) and simulation (green, orange) trajectories within the left turn scenario (© Deutsches Zentrum für Luft- und Raumfahrt e. V. (DLR))

- Simulations can be adjusted through various fine-tunings to be close to reality
- Deviations can nevertheless be observed, the measure of the maximum permissible deviation must be selected depending on the application
- Detection failures (such as ghost objects for LiDAR) are underrepresented in employed sensor models
- For the validation of a simulation component (a LiDAR model), see [Poster #14.2]

Conclusions

The activity demonstrates the ability of simulation to accurately replicate reality and validate SAE 4 automation systems.

Application Example

Partners

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