Validation Of Automated Driving

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Eco-System in Automated Driving

Source: AutoSens Conference (www.auto-sens.com), Vision Systems Intelligence, LLC. (www.vsi-labs.com)
How to avoid this? .... and achieve that?

How to make sure that the automated vehicle behaves correct in EVERY situation?
Automated vehicle and environment interact

A Complex System …

… in a Complex Environment

Traffic situations

Road conditions

Driver behavior

Weather conditions
ADAS/AD System Validation Challenges

- Automated vehicles are most complex cyber physical systems
- Environment interacts with automated vehicle
- Uncountable number of scenarios
- Critical scenarios occur only rarely
- AD sensors imperfect in rough weather conditions

- Only road testing not enough
- Virtual testing required too
- Artificial intelligence requires new validation methods

Source: Prof. Dr. Ing. Philipp Slusallek / DFKI: Artificial Intelligence & Digital Reality - Do we need a "CERN for AI"
Six different ADAS/AD test tasks:

- Sensor validation
- Sensor model calibration
- ADAS/AD sensor fusion validation
- ADAS/AD function validation
- ADAS/AD vehicle validation
- Homologation

ADAS/AD Validation Tasks

- Sensor Development, Sensor verification
- Sensor Benchmarking
- Sensor Training, Validation & Model Calibration
- Sensor fusion development & verification
- ADAS / AD Function Development & Verification
- Sensor fusion development & verification
- ADAS / AD vehicle Validation
- Test Verdicts
- Homologation
Accelerated ADAS/AD System Validation required

Potential **Acceleration** measures for ADAS/AD System Validation:

1. Virtual Validation: Perform tests in virtual environment using high performance parallel computing
2. Select relevant Scenarios: Test only relevant scenario from real world driving (which may cause safety issues)

**Problem:**
- Excellent simulation models of vehicle, driver, sensors as well as replica of ADAS/AD SW strategy required
- Otherwise “another” vehicle is validated

**Acceleration** measures:
3. Identify edge-cases in virtual environment
4. Test edge-cases using real sensors
5. Use road testing to validate virtual tests (models, scenarios)
Scenario based ADAS/AD Verification and Validation Tool Chain

**Scenario Preparation**
- Scenarios to test requirements (DVPs)
- Synthetic random scenarios
- Scenarios from road data

**Model Preparation**
- Sensor model Editor
- Generic Sensor Model
- Specific Sensor Model

**KPI Preparation**
- Sensor model Parametrization
- ScenarioDBs Models KPIs

**Test Case Preparation**
- Test Sequence Generator
- Environment Simulation

**Data Management**
- Online / Offline Evaluation & Postprocessing

**Test Execution**
- Signals, Object lists, Streams (Video, 3D, ..)
- Public Road Testing using reference DAQ
- Private Test Track
- VIL (Driv.Cube™)
- Driving Simulator
- ML/SIL
- Cloud MIL/SIL

**Model.CONNECT™**
Sources for Validation Scenarios

- Scenarios relevant for ADAS function
- Scenario parameter ranges
- Environment conditions (daylight, fog, rain, traffic type, ..)

Scenarios, parameters and statistics are extracted and stored

Excerpt of criteria:
- Scenario parameter ranges
- Environment conditions (daylight, fog, ..)

List of scenarios with variations
Virtual Test Environment

Co-Simulation Framework

- ADAS/AD functions
  - Sensor output with performance indicators
  - System-under-Test
  - Augmented and validated sensor models

Virtual Environment

- Static Scenario Content (Lanes, traffic signs, barriers, …)
- Dynamic Scenario Content (other vehicles, pedestrians, dynamic traffic signs, …)
- Scenario parameters (e.g. weather conditions)

Source: RobustSense research project funded by European Commission and National funding authorities

Tools:
- OSI
- FMI
- OpenDrive
- OpenCRG
- OpenFlight
- OpenScenario
Cloud Simulation to Identify Critical Scenarios

- Simulation models never completely match behavior of real components
  - e.g. behavior of sensor models in severe weather conditions
- Results of high performance parallel simulation only indication of ADAS/AD performance in critical situations
- Additional tests with real components required
  (Verification of model performance)
Cloud Simulation to Identify Critical Scenarios

Define Digital Twin
- Vehicle modelling (e.g., AVL VSM™)
- Automatic model calibration
- Sensor models

Test Sequence Generator
- Define test sequence with parameter variations (experiment)

Test Scenario DB
- Synthetic test scenario
- Measurement Based Test Scenario

Scalable simulation environment
- Identify critical regions

Validation of system performance in critical scenarios using more detailed models or real components
Dangerous vehicle scenarios tested in save environment: AVL Driving Cube
Video Sensor and Radar Sensor Stimuli

- Visualization System
- Radar stimulus
- Steering Actuator
- Torque Actuator
- Ultrasonic Stimulus
- Simulation Platform
- Reflection parameter calculation
- Log range reflection simulation
- Short range reflection simulation
- Signal preparation
- Antenna array
- Vehicle Radar Sensor
- Object visualization
Video Sensor and Radar Sensor Stimuli
Steering Force Stimulus
Summary

- Virtual validation is key to cope with complexity of ADAS/AD validation
- Real world testing also required due to differences of digital twin and real twin
- Scenarios are base
- They come from requirements/analysis, real world data, synthetic data
- Models critical
- Model parametrization to adapt generic models to specific models essential
- Model validation significant effort
- Sensor stimulation enables near real-world tests in safe environment