Open Standards as a Leverage for the Development of Automated Driving

ASAM International Conference, December 11th 2019
Motivation

Why do we need closed-loop simulation and (OpenX) standards?

- Still valid, but: *yesterday’s news:*
  - **Increased front-loading** to avoid costly changes in late development phases
  - **Deterministic controllability** of vehicle and environment test conditions
  - Safe testing in **critical driving maneuvers**, including near crash situations or vulnerable road users

- Simulation is an **integral part of the development of automated driving:**
  - New **software development processes**
  - Interdisciplinarity leads to diverse tooling and **increased importance of standards**
  - Increased quantity and quality of **scenarios**
Standards for Key Components of Virtual Test Driving

Static Environment
- road profile, network
- friction, roughness, ...
- lane markings, guard rails, traffic signs, signals, ...
- terrain, buildings, vegetation
- lighting, fog, precipitation

Dynamic Environment
- vehicles, bicycles, pedestrians, animals
- deterministic tasks or stochastic traffic
- interaction with other road users and reaction on events

Vehicle Model
- chassis, steering, tires, ...
- engine, electric motor, ...
- drivetrain components
- electrical system, ...
- vehicle state sensors for yaw rate, acceleration, ...

Sensor Models
- camera, radar, lidar, ultrasonic
- object lists, target lists or physics-based sensor data
- realistic sensor movements due to vehicle dynamics

Toolchain Integration
- integration of system under test into vehicle model
- integration of simulation application into various execution environments from MiL to HiL
- test automation
- reporting
- management of result data and parameters
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Standards for Key Components of Virtual Test Driving

Input

System under Test

optional: custom sensor model

Simulation & Workflows

Output

ASAM
OpenDRIVE

ASAM
OpenSCENARIO

ASAM
XiL API

DYNA4

ASAM
OSI

ASAM
MDF
Use-Case: Explorative Testing of a Highway Pilot

Use-Case Description

- Test system performance of **highway pilot** function
  - uses vehicular environment perception sensors
  - enhanced with C2X functionality

- Testing scenario with Vehicle under Test:
  - on a highway
  - approaching a traffic jam caused by a broken down vehicle
  - in varying surrounding traffic

source: Daimler.com
Use-Case: Exploratory Testing of a Highway Pilot

OpenDRIVE Road Model

Input

ASAM OpenDRIVE

Simulation & Workflows

System under Test

optional: custom sensor model

Output

ASAM OSI

ASAM MDF

ASAM OpenSCENARIO

DYNA4

ASAM XiL API
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OpenDRIVE in DYNA4

- ASAM **OpenDRIVE** standard for parametrical road model and static environment
  - Complex road networks with junctions, crossfall, superelevation etc.
  - Road marks and barriers, traffic signs and traffic lights, gantries, etc.
  - Integration of high resolution road surface profiles in OpenCRG format
- Direct **support without conversion** in DYNA4
  - Online generation of road and terrain for simulation and 3D visualization
  - Simulink block for online access to “ground-truth road data”

German highway A9 measured and exported to OpenDRIVE by 3D Mapping Solutions
Use-Case: Exploratory Testing of a Highway Pilot

Enhancement of OpenDRIVE roads with custom-made environments

Windridge City by unity

Wangen by TRIANGraphics

Intelligent Terrain Solutions
What is SUMO?
- Free and open traffic simulator
- Part of Eclipse openMobility group
- Simulation of Urban Mobility
- Main contributor: German Aerospace Center

OpenDRIVE support in SUMO
- Proprietary XML network format for SUMO
- Conversion from OpenDRIVE via SUMO’s integrated NETCONVERT tool
- Reduction of manual effort through customizable mapping of OpenDRIVE
Use-Case: Explorative Testing of a Highway Pilot

OpenSCENARIO

DYNA4

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Traffic and Dynamic Environment

- Current solution: proprietary scenario description
  - Assign paths or routes to road users (vehicles, cyclists, motorbikes, pedestrians, animals)
  - Trigger longitudinal or lateral driving tasks such as lane changes for deterministic behavior
  - Enhance deterministic traffic with stochastic road users

- Upcoming: OpenSCENARIO
  - Active contribution to OpenSCENARIO 2.0

- Expectations / hopes:
  > Standardized, yet extensible scenario description language
  > Unified mechanism for 0, 1 or n Vehicles under Test + deterministic traffic + stochastic traffic
Use-Case: Explorative Testing of a Highway Pilot

Driving single VuT on highway in stochastic surrounding traffic

Vehicle under Test

Scene in traffic simulator SUMO

Scene in visualization of DYNA4
Use-Case: Explorative Testing of a Highway Pilot

OSI

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ASAM OpenDRIVE

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Use-Case: Explorative Testing of a Highway Pilot

Simulated Sensor Data

- Sensors are crucial for environment perception of ADAS/AD algorithms

- Simulator provides sensor data depending on boundaries of system under test:
  - (sensor-specific) **object lists** or
  - technology-specific **raw data**

- Object lists are often sufficient for closed-loop simulation

- But **mapping them across tools is tedious!**
  - Reference coordinate systems
  - Object types
  - ...
Use-Case: Explorative Testing of a Highway Pilot

Example: Testing the Sensor Fusion ECU (Hardware)

Planned for 2020:
- Sending object lists from DYNA4 as OSI Byte Array
- Receiving OSI Byte Array in CANoe
- OSI conform object list definition within CANoe
Use-Case: Explorative Testing of a Highway Pilot

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Execution of DYNA4 Models in other Environment

- Authoring of Models, Parameters and Scenarios with DYNA4 Studio
- Headless Execution of DYNA4 Run in other environment: ADTF, CANoe, ROS, Windows / Linux Executable, ...
Use-Case: Explorative Testing of a Highway Pilot

C2X Simulation in CANoe executing a DYNA4 Model with SUMO

Vehicle under Test
Use-Case: Explorative Testing of a Highway Pilot

MDF
Use-Case: Explorative Testing of a Highway Pilot

Standardized result data analysis with MDF

- Many scenarios and many virtually driven kilometers generate a lot of data
- Generation of MDF files as result data files for seamless result data analysis without conversion
- DYNA4 MDF support: Q2 2020
Open Standards for the Simulation of Automated Driving

- Single vehicle
- Simple and short scenario
- Interaction with environment only through road contact
- Simple animation for verification purposes
- Stand-alone usage on a desktop machine

- Deterministic traffic, stochastic traffic and multiple vehicles under test.
- Complex scenarios based on OpenDRIVE to reflect real-world driving. Soon: OpenSCENARIO.
- Detailed environment simulation and sensor models on different levels. Soon: Support of Open Simulation Interface.
- Flexible integration in existing toolchains through interfaces or headless model runtimes. Soon: Result analysis based on MDF.

Multiple Vehicles under Test in Platooning setup

Lidar point cloud displayed in ROS RViz
Thank you for your attention.

Any questions?
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