Co-simulation of the virtual vehicle in virtual traffic considering tactical driver decisions

Dr. Jakob Kath, Product Management Engineer
jakob.kaths@tesis.de
+49 89 74 7377-63
Vector Informatik GmbH

Employees: > 2,500
Headquarters: Stuttgart

Product Examples for Testing applications and ECU calibration:
CANoe, CANalyzer, vTESTstudio, VT System, CANape, vADASdeveloper

Vehicle simulation since 1985
Member of the Vector Group since 2019
Headquarters in Munich, Germany
Simulation products and services
Worldwide customer base
Automated driving - many questions require multiple tools

How do automated vehicles influence road capacity?
⇒ Microscopic traffic flow simulation, e.g. SUMO

What sensor set is necessary for the driving function to work safely?
⇒ Vehicle and environment simulation, e.g. DYNA4

How does traffic influence the efficiency of assisted and automated driving?
⇒ DYNA4 + SUMO
**Vehicle Simulation vs. Microscopic Traffic Flow Simulation**

**virtual vehicle**
DYNA4

- virtual vehicle with high fidelity driving dynamics, MBS axles, drivetrain and sensor models
  → yaw rate, wheel rotation...

- testing in deterministic scenarios for accurate reproducibility

**virtual traffic**
SUMO

- hundreds of vehicles with human-like car following and lane changing behavior
  → number of stops, travel times, ...

- stochastic traffic scenarios to account for variation in real world

- direct support of OpenDRIVE road format

- integration of vehicular control systems from MiL to HiL for ECU tests

- included conversion from OpenDRIVE format

- SiL integration of traffic signal controllers

**the virtual vehicle in the virtual traffic**
Key Components for Virtual Testing of ADAS and Automated Driving

Vehicle under Test (VuT)
- Realistic vehicle dynamics
- Actuation of brakes, steering, etc.
- Vehicle states sensors
- Driving tasks for driver

ADAS/AD functions under test
- Control algorithms for MiL/SiL testing
- Hardware controller for HiL testing

Customer

Environment Sensors
- Camera, radar, lidar, ultrasonic
- Vehicle dynamics, which are impacting sensor movement

Traffic
- Vehicles, bicycles, pedestrians, animals
- Deterministic tasks or stochastic traffic
- Interaction with other road users and reaction on events

Road & Environment
- Road, lane markings
- Traffic signs, traffic signals
- Terrain, buildings, vegetation
- Lighting, fog, precipitation
Deterministic Traffic Scenarios in DYNA4

- Assign **paths or routes** to traffic participants
- Use deterministic events to trigger **longitudinal or lateral driving tasks** such as lane changes
- Control **lighting and weather** of the scene in simulation scenarios
Simulink traffic block with open interfaces to control road users with external software, maintaining full availability of DYNA4 features

- Ready-to-use solution for SUMO

- Stochastic, yet reproducible complex traffic scenarios with „one-click“ scenario variation

- Combining deterministic traffic with stochastic traffic

- Example: Influence of traffic volumes on a cooperative driving function
performant subscription to traffic objects surrounding VuT with optional semi-circle extension

combination with additional deterministic traffic by DYNA4

full availability of DYNA4 features including Simulink-based sensors and GPU-based sensors by looping SUMO traffic through DYNA4 traffic

modular integration of SUMO by using C++ TraCI API within Simulink S-Function
Co-Simulation of DYNA4 and SUMO (II)

**S-Function C++**

- SUMOstep?
  - yes: set VuT
  - no: position, speed, angle...

**SUMO step (10Hz)**

- get traffic information
- traffic objects left?
  - yes: position, speed, angle...
  - no: interpolate traffic information

**DYNA4 step (1000Hz)**

VuT: Vehicle under Test
Enhancing a Driver Model in times of AV?

- Automated driving function not (fully) available
- Highly divided function developments between departments and different companies (OEM vs. Tier1)
- Early testing of parts of automated driving functions
- Example: Object detection in urban scenario

Virtual test driving on OpenDRIVE motorway with DYNA4 and SUMO traffic
Including Tactical Lane Changes from SUMO

S-Function C++

SUMOstep?

no

position, speed, angle…

yes

set VuT

SUMO step (10Hz)

get traffic information

traffic objects left?

no

position, speed, angle…

traffic signal timings

yes

interpolate traffic information

+ enhanced Driver Model

DYNA4 step (1000Hz)

+ getLaneChangeState

VuT: Vehicle under Test
Tactical Driver Decisions for Lane Changing

- Successful integration of SUMO’s tactical lane choices
- At times behavior can be observed that purely SUMO controlled vehicles would not show
- SUMO lane-change parameters can be used to influence the Vehicle under Test efficiently
Summary & Outlook

- DYNA4 and SUMO Co-Simulation extended by combining SUMO’s tactical behavior with DYNA4’s operational behavior

- In-depth analysis of information quality after moving Vehicle under Test (currently skipping move improves quality)

- Extension to SUMO’s driver reaction on traffic signals and right-of-way (currently no TraCI equivalent to getLaneChange)

- Evaluate possibility to switch to libsumo to avoid TraCI communication overhead
Thank you for your attention!