Automotive Needs and Expectations towards Next Generation Driving Simulation

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DSA

Insight from Outside
analyze – visualize – understand

Source: Daimler AG

“Automotive Needs and Expectations towards Next Generation Driving Simulation“

by Dr. Hans-Peter Schöner

Abstract *– The purpose of driving simulation has developed over the years, and this is continuing and accelerating with the rise of autonomous vehicle development. Technical key topics have changed in the past, and also relevant questions for the application of simulator experiments have changed over time. In the near future the scope of driving simulation topics will extend into some new directions and thus generate new requirements. This presentation discusses the technical challenges of simulation tools which deduct from these requirements; the challenges will guide the main research topics of the coming years and set the frame for future content of the Driving Simulation Conference.*

Driving Simulation Association

driving-simulation.com

Overview

1. Changes in Simulation Focus
2. Sensor Models and their Applications
3. Realistic motion modelling of pedestrians and bicycles
4. Interaction between several traffic participants
5. Valid distance perception
6. Massive simulation with parameter variations of the scenarios
7. Driving simulation as a software development tool
8. Simulation and its validation on proving grounds

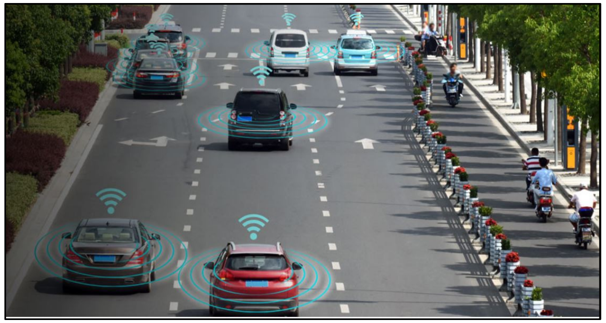
Changes in Simulation Focus

Focus in the past extended from:

- **how does it feel?**
  (with respect to comfort, safety and controllability)
- **how does it look?**
  (with respect to driver's work place visibility and accuracy of virtual roads, for example specific race tracks)

towards

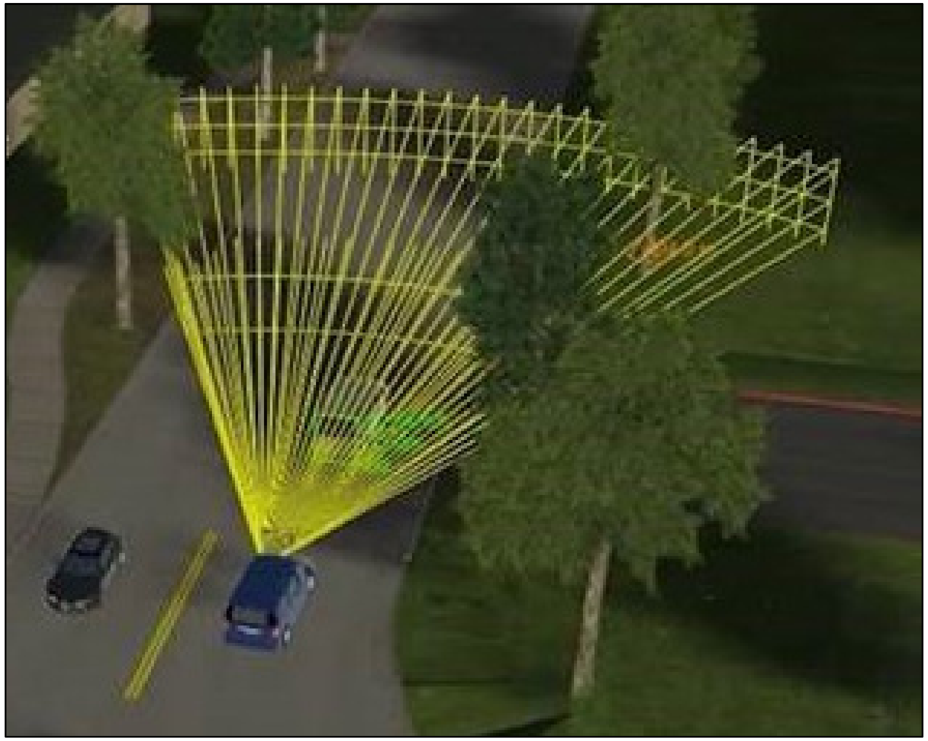
- **how well does the driver react?**
  (with respect to situation understanding and design of human machine interface)



The scope of driving simulation topics develops further into:

- how does the driver and passenger **perceive the traffic situation**?
- how can simulation effectively **support software development**?
- how can simulation significantly **support functional testing**?
- how can simulation support the **entire vehicle testing chain**?

Sensor Models and their Applications



<u>Relevant sensor types:</u>

- Camera
- Radar
- Lidar
- Ultrasonic
- GPS-position
- Map*

*) precise, but possibly outdated environmental information

When human drivers are replaced by sensor-based driving software, sensor models replace the optical rendering for human eyes (and brains)

Sensor Models and their Applications

Ground Truth Model
provides the complete knowledge about all neighbouring objects in the virtual environment

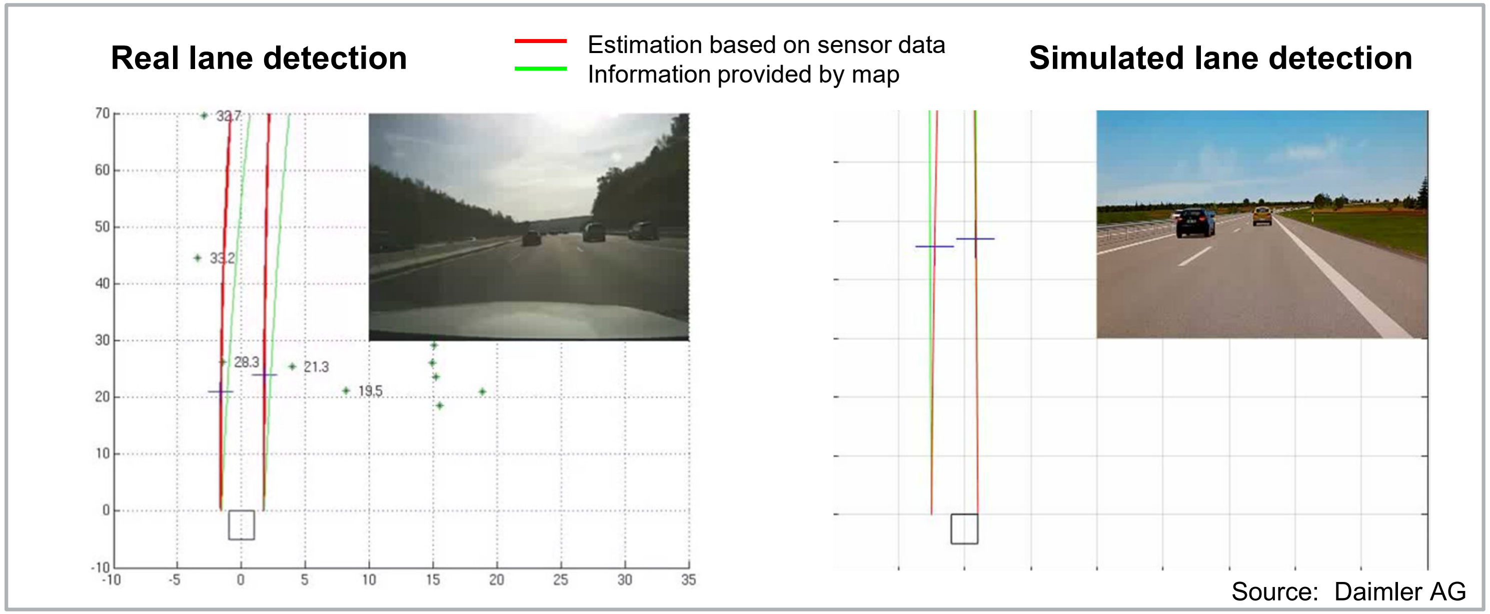
Geometric Model
provides information masked by the viewing angle and the maximum range of the sensor, and also considering geometrical object occlusion

has been used commonly for controlability studies of ADAS systems in ***Driver in the loop*** simulations, for example in order to generate a warning tone and emergency braking functions

used in order to evaluate the basic function of a vehicle in **complex traffic situations**, including effects resulting from the geometrical position of **several contributing sensors**

Sensor Models and their Applications

Stochastic (or Statistical) **Model**
implements a first stage of imperfection of the sensor information w.r.t. precision, noise and correctness



used to verify the ability of the environmental perception software to handle **imperfect sensor input** and to take advantage from the knowledge about different sensor properties in **sensor fusion;** evaluate, under which sensor conditions the fusion reaches its **functional limits**.

Parameters describing the stochastic distribution depend on

- the sensor type (cameras have a relatively good lateral, but poor longitudinal resolution, radars have complementary properties),
- Geometry (viewing angle, object distance, …)
- weather and lighting conditions

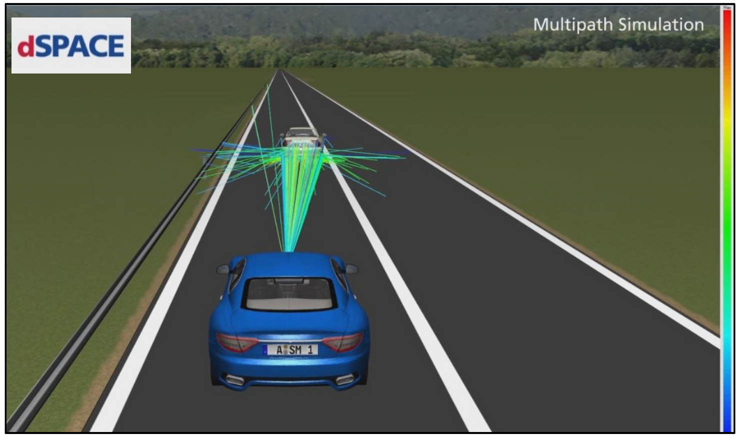
and should be **collected in real world measurements**

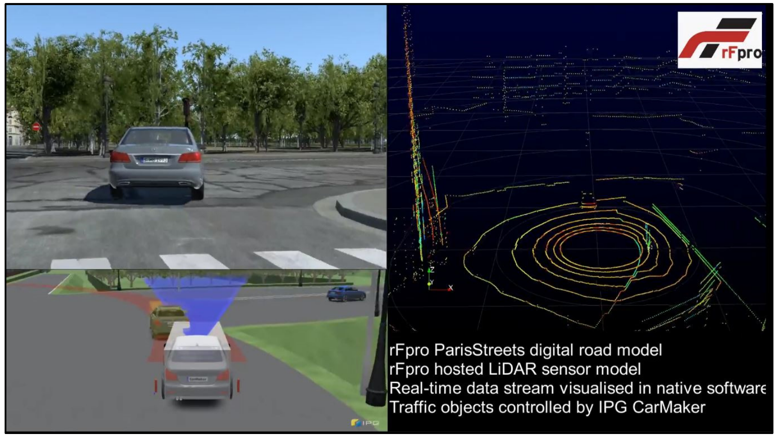
easily switch between different parameter sets in order to assess the dependence on sensing quality

Sensor Models and their Applications

Physics-based Model
uses physical properties of all objects in the virtual world to simulate the effect of reflections and absorptions on active sensor signals, respectively the "visibility" under different ambient lighting or “noise” conditions

Requires the parameterization of <u>all relevant objects</u> in the virtual world with respect to sensor “visibility” and the real-time calculation of the interaction (ray tracing).





study the effect of specific use cases, especially **reflections**, or any other **singular effects** on sensor **fusion performance** or **robustness** of the driving function; essential for **sensor development**; might even be used to **find unforeseen effects** while driving through a virtual world.

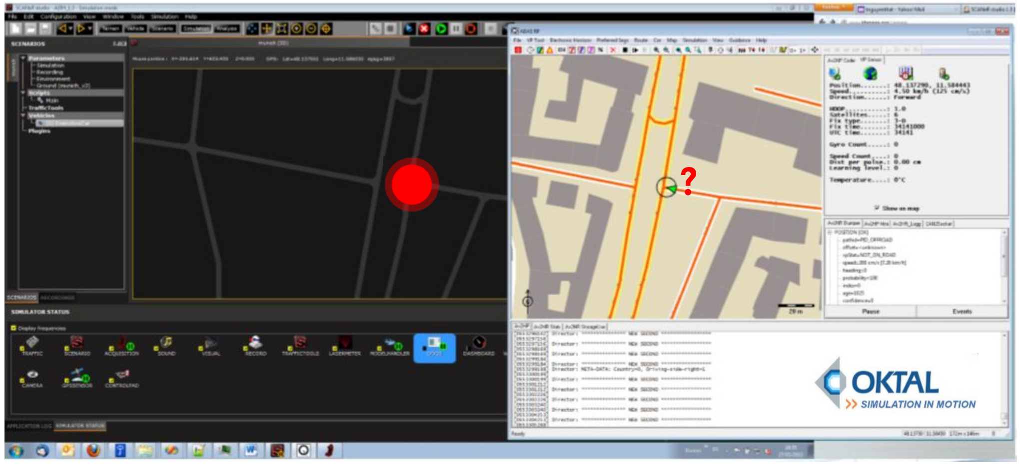
easily switch between environmental conditions and object parameters in order to assess the dependence on weather / lighting / object type

Sensor Models and their Applications

Phenomenological Model
implements certain behaviour patterns of sensors (incl. GPS or map), which might occur during special conditions like glare, reflections, saturation, noise, temporary signal interruptions, temporary false signals, incorrect map information, ...

GPS sensor

Send Latitude, longitude, altitude through the network



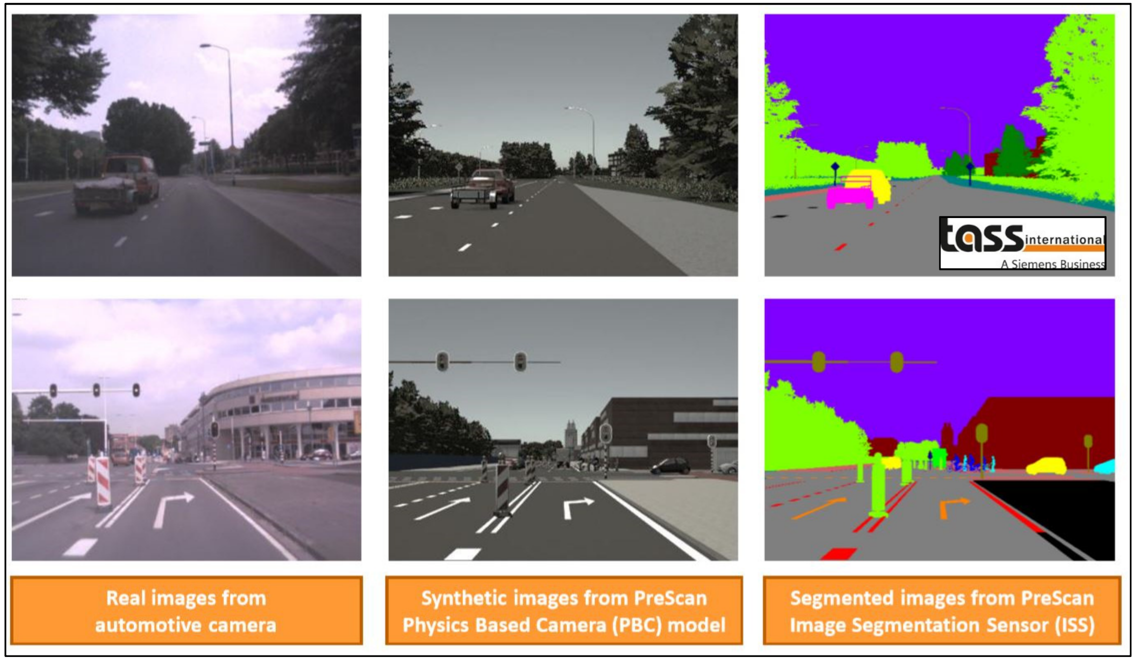
study the effect on **sensor fusion**, on **fault rejection algorithms** or in general on the **robustness** of a sensor set, when **rare phenomena** of each sensor type occur **in combination**.

Typical signal patterns (phenomena) which deviate from average behaviour may be the results from test drives with a single sensor type; the simplified and abstracted behaviour can be applied in the simulation at arbitrary trigger points.

easily combine and trigger different phenomena in order to assess the influence of rare phenomena

Sensor Models and their Applications

Ground Truth Model combined with **Physical Model**
takes advantage of perfect knowledge about the virtual world
in combination with close to reality rendered scenes
provided to a single sensor or to complete sensor sets



used to **train deep-learning supervised systems**

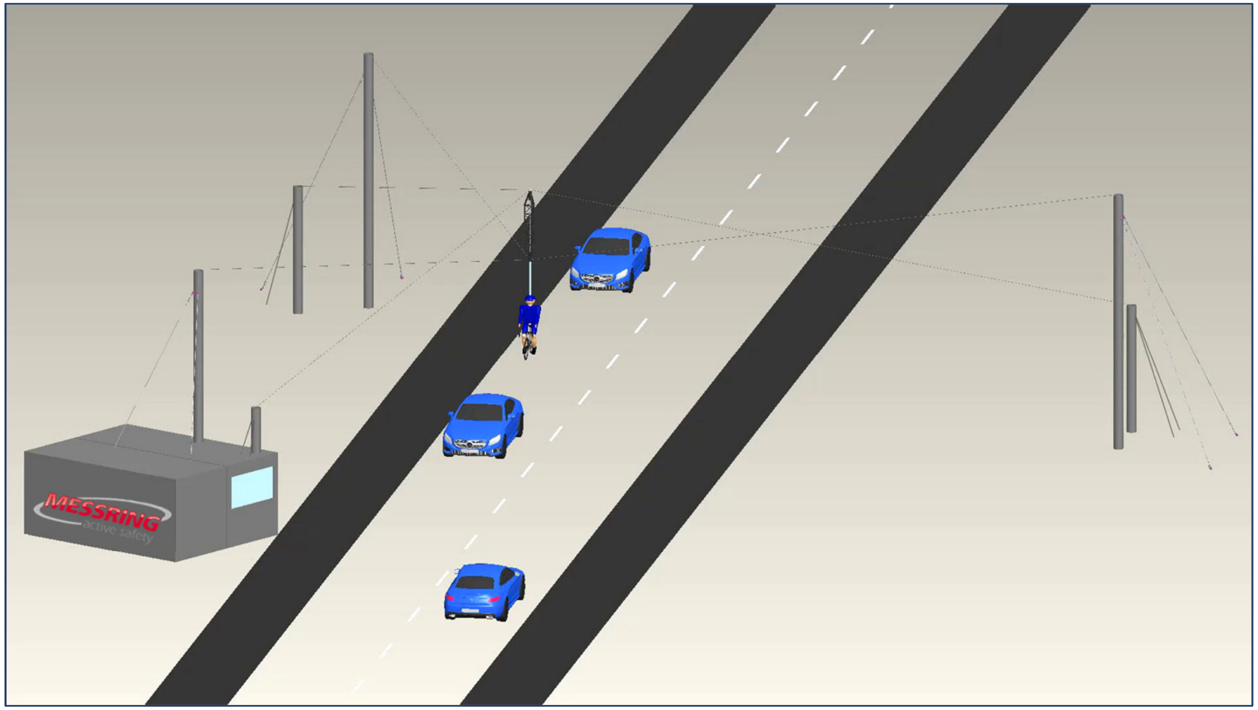
Realistic motion modelling of pedestrians and bicycles

Is the motion of a simulated pedestrian realistic enough for the new applications of simulation ?

Realistic motion modelling of pedestrians and bicycles

Inclination is the early indication of change in motion direction

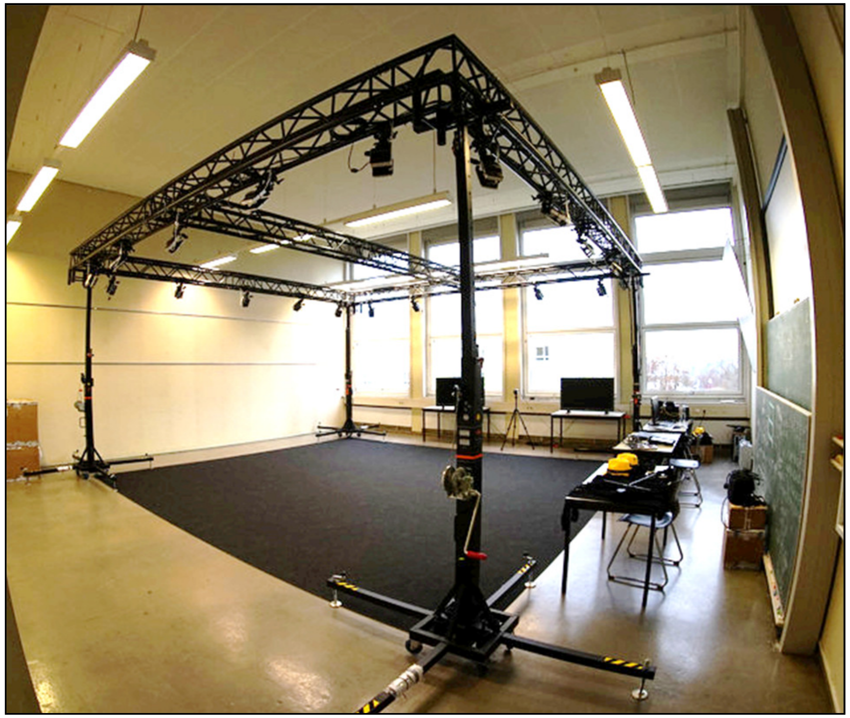
Realistic motion modelling of pedestrians and bicycles

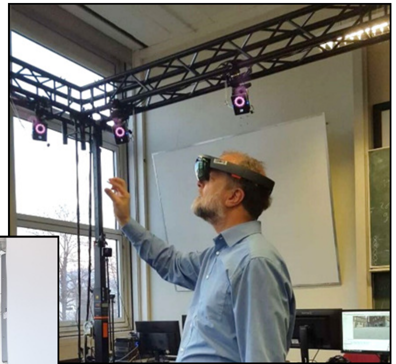


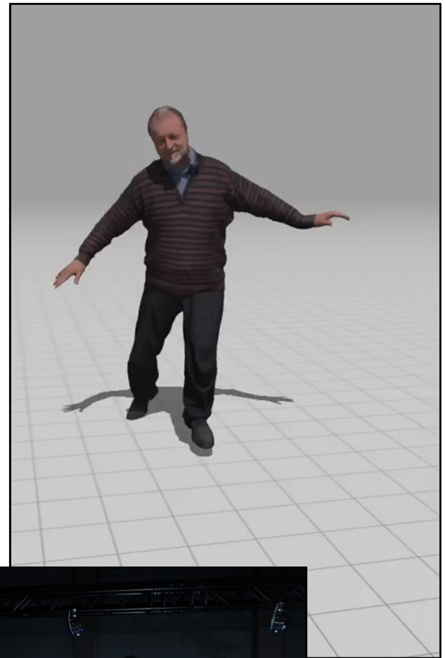
Proving ground systems with extended capabilities will copy motion from simulation worlds

Realistic motion modelling of pedestrians and bicycles

MoCap4.0 at University of Reutlingen





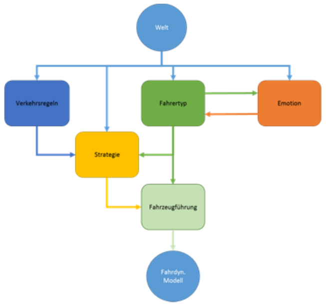


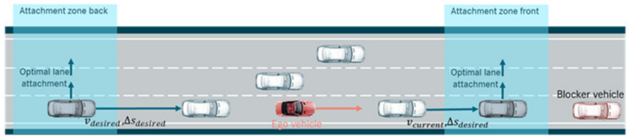
For simulation of Vulnerable Road Users (VRU) and for interactions with AVs from outside

https://cogsys.reutlingen-university.de/

Interaction between several traffic participants

Source: Kober, Ch.: Fahrermodelle und Umgebungsverkehr in der digitalen Erprobungsfahrt. 9th IBS Workshop Automotive Software Engineering, Chemnitz, 2018

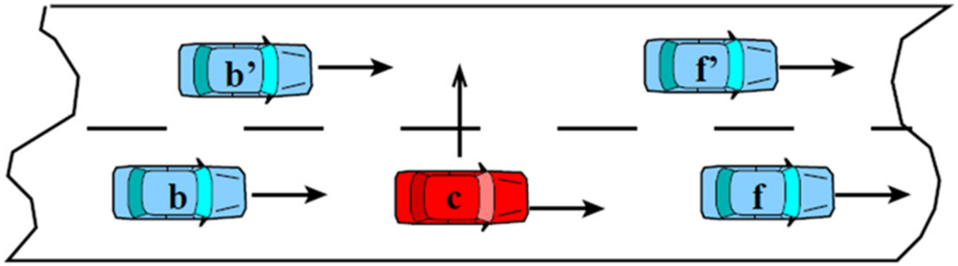




Driver → Vehicle → Simulation environment → Interaction → Traffic

→ Realistic traffic flow results from interaction of various driver types in vehicles with different performance

Emotions significantly influence driver behaviour



choice of speed and time gap as well as
lane choice and lane change behaviour

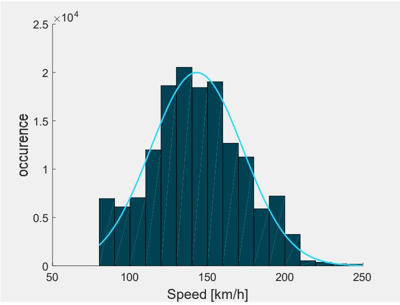
Source: Kober, Christopher: Fahrermodelle und Umgebungsverkehr in der digitalen Erprobungsfahrt. 9th IBS Workshop Automotive Software Engineering, Chemnitz, 2018

Especially critical situations evolve from behaviour under fatigue, stress or anger

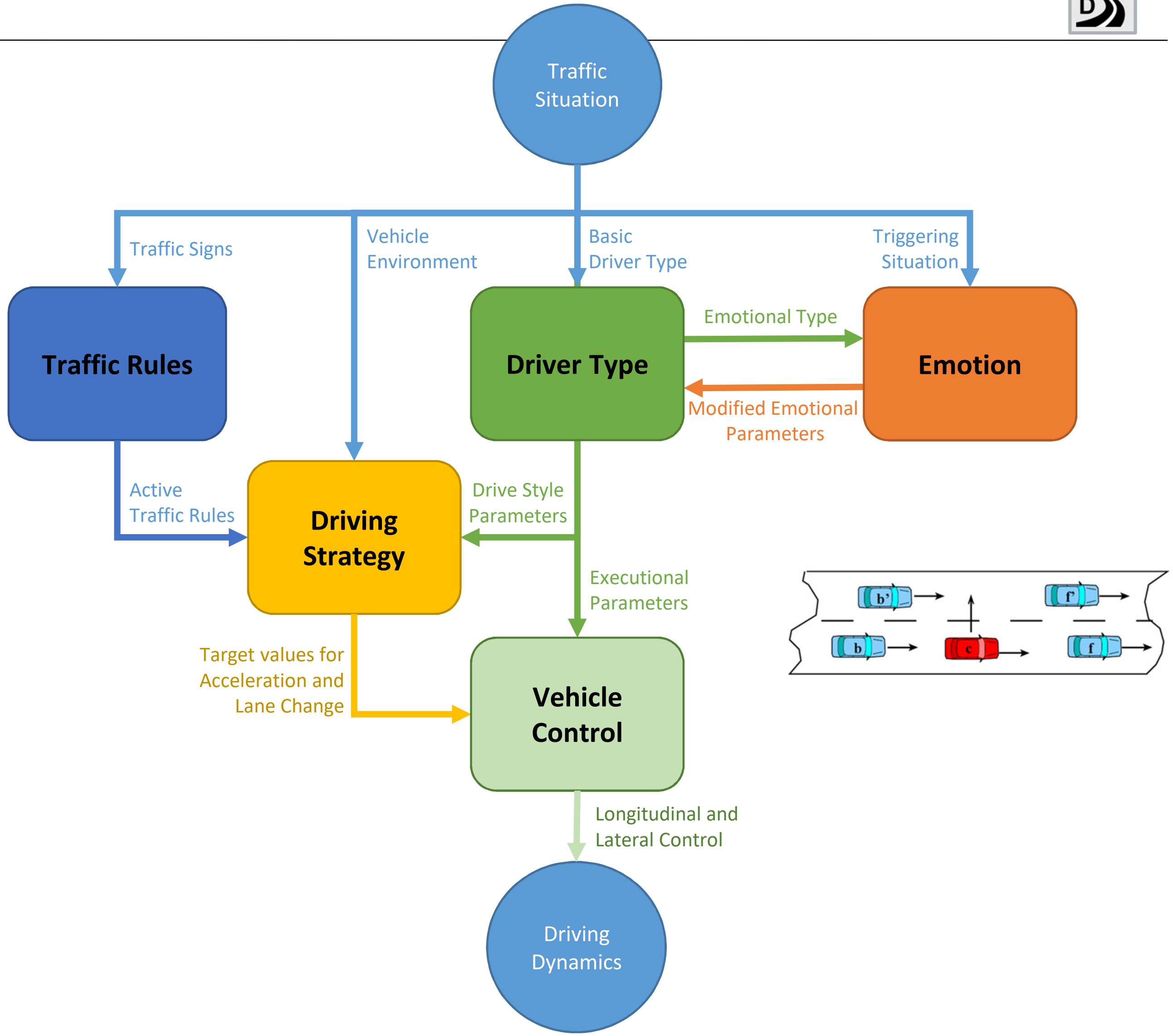
Interaction between several traffic participants - example

Source: Kober, Ch.: Fahrermodelle und Umgebungsverkehr in der digitalen Erprobungsfahrt. 9th IBS Workshop Automotive Software Engineering, Chemnitz, 2018

Driver Model according to Kober

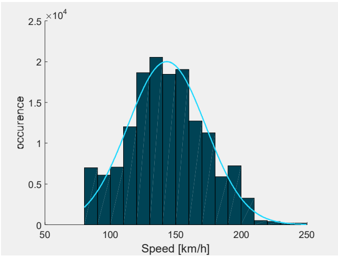


Driver Type	calm	active	spor-tive	affec-tive	unse-cure	aggre ssive
Occurence	35%	31%	11%	11%	6%	6%
Speed choice	o	+	+	o	-	+
Safety	+	+	-	-	+	-
Consideration	+	+	o	-	+	-
Skills	+	+	+	-	-	+
Emotions	o	o	o	+	-	+



Source: Kober, Christopher: Fahrermodelle und Umgebungsverkehr in der digitalen Erprobungsfahrt. 9th IBS Workshop Automotive Software Engineering, Chemnitz, 2018

Interaction between several traffic participants



Driver Type	calm	active	Spor-tive	Affec-tive	Unse-cure	Aggre s-sive
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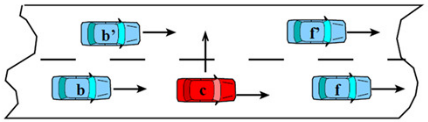
Safety	+	+	-	-	+	-
Consideration	+	+	o	-	+	-
Skills	+	+	+	-	-	+
Emotions	o	o	o	+	-	+



Realistic highway traffic flow is available, realistic city driving still a challenge !

Valid distance perception

Schmieder H., Nagel K., Schöner H.P.: Enhancing a Driving Simulator with a 3D-Stereo Projection System; Driving Simulation Conference, Stuttgart, 2017

Especially in city driving situations the correct distance judgement is critical

Stereo images in the driving simulator
(both channels, as seen without filter glasses)

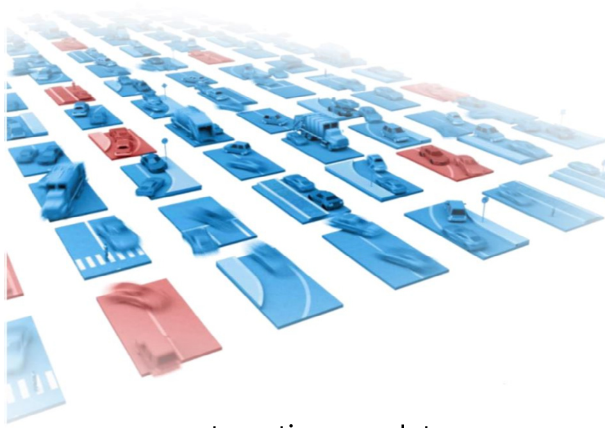
Mono images in the driving simulator
(alternating view of left and right eye)

Stereo images in the driving simulator
(alternating view of left and right eye)

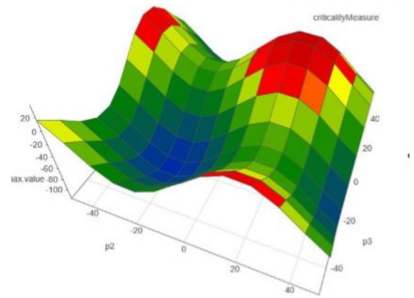
Massive simulation with parameter variations of the scenarios

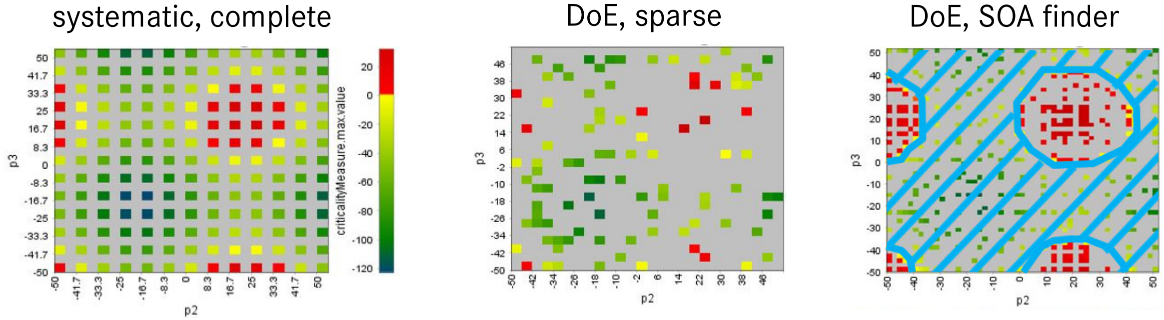
Simulation Tool Challenges

- Faster than real time (?)
- Parallel processing
- Efficient turn around time
- Easy configuration and integration
- DoE methods for coverage of the huge parameter space
- Calculation and sharing of performance measures



Source: Tatar M.: Chasing critical situations in large parameter spaces. Autonomous Vehicle Test & Development Symposium Europe, Stuttgart, 2018



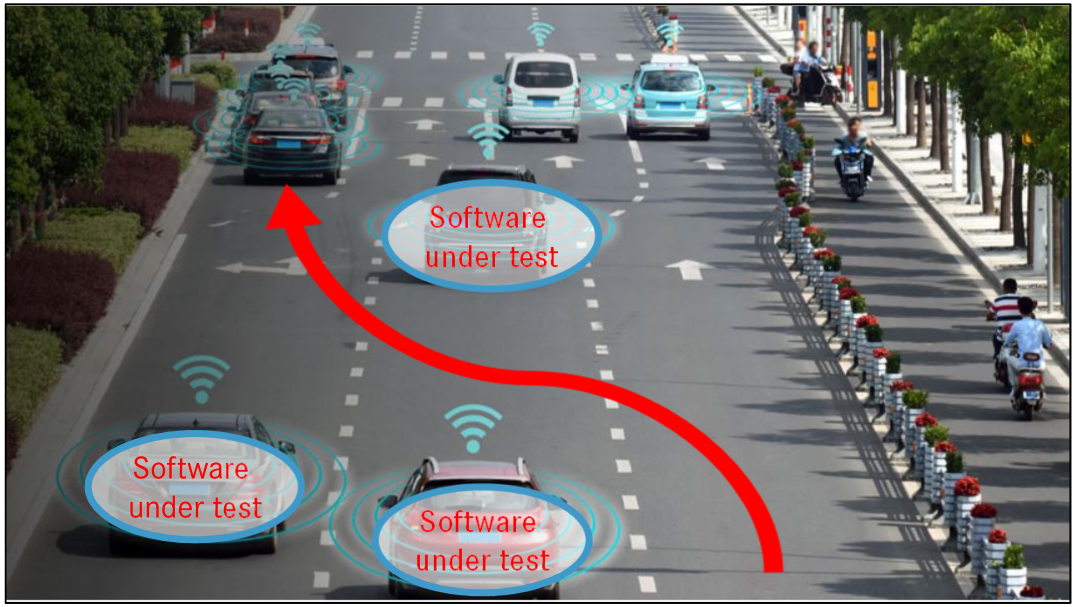


Extraction of performance measures from a simulation run is essential for finding safe operational areas

Driving simulation as a software development tool

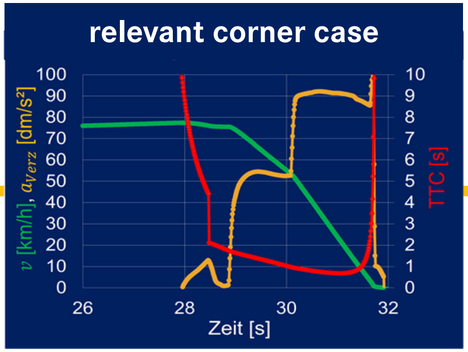
Interactive SW-development and functional testing workplace

Driving simulation as a software development tool



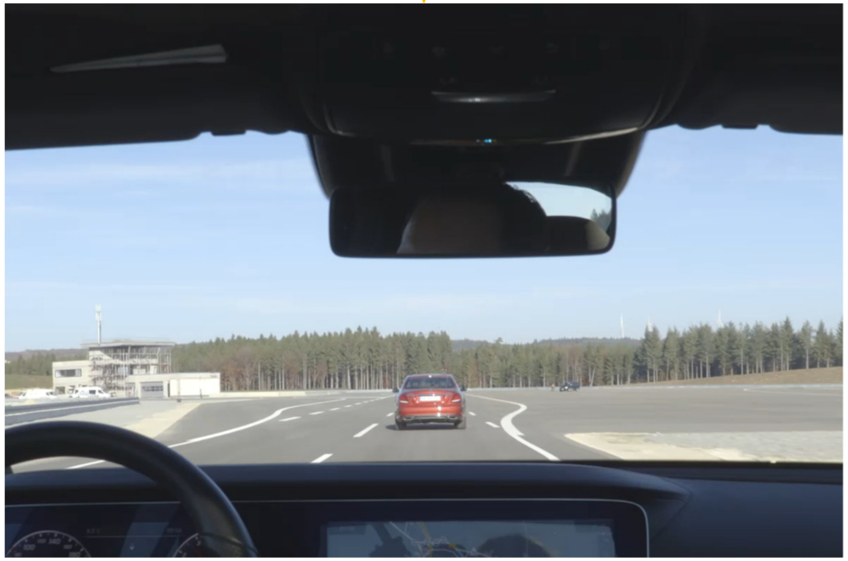
Emergence of a different perspective in the use of simulators:
from *"driving in the vehicle under test"* to *"challenging the AV from outside"*

Simulation and its validation on proving grounds

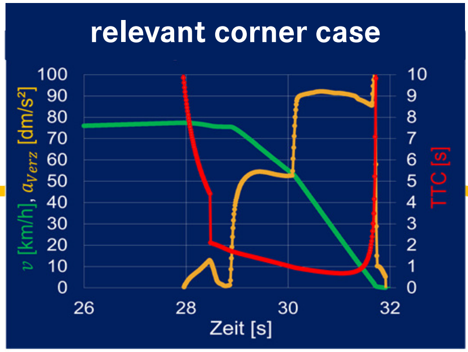


Simulation

Proving Grounds

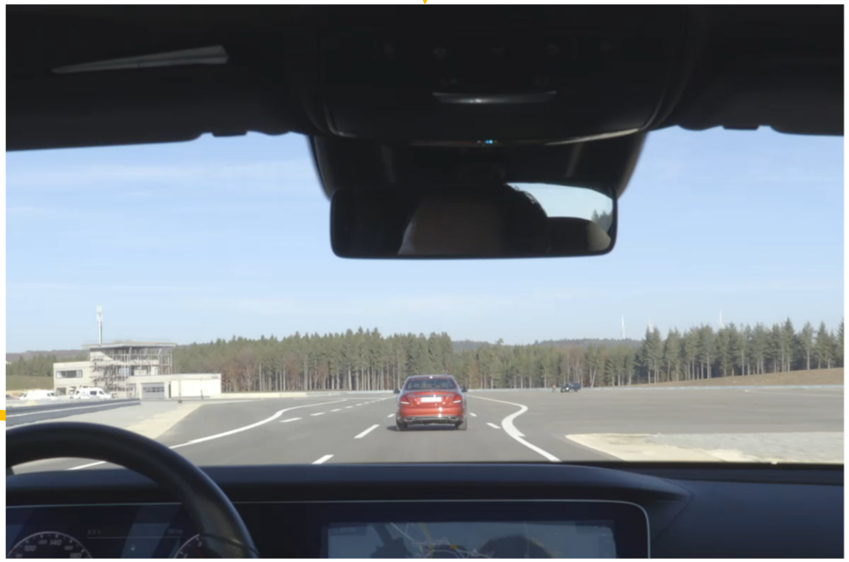


Simulation and its validation on proving grounds



Simulation

Proving Grounds



Common data interfaces for scenarios, and same metrics

Summary

Simulation-based vehicle software development
and functional verification and validation

is a wide field of actions for academic research
and
pre-competitive cooperation between OEMs.

One more thing...

Thank you !

Have an interesting conference !

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Round Table Discussions

Simulation data interface standardization	***Fitzgerald Room***
Interactions in VR environments	***Armstrong Room***
Operational Standards for driving simulators	***Davis Room***

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About the Author

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Dr. Schöner has retired in 2018 from his development position at Daimler AG in Sindelfingen. He is now working as an independent consultant at „Insight from Outside“-Consulting, and he is „Senior Automotive Expert“ in the Driving Simulation Association.

Until March 2018 he was Senior Manager "Testing Concepts and Test Site" (RD/ASK) in Daimler's R&D Center "Assistance Systems, Active Safety and Testing". In this and former positions, he was responsible for development and supply of methods for testing and validation for future chassis and assistance systems, including autonomous driving functions. This included methods to provide reproducible testing situations on proving grounds with automatically driven coordinated vehicles, simulation methods and proving facilities for function development and testing, and operation of the Driving Simulation Center of Daimler AG.

Dr. Schöner (born 1956 in Düsseldorf) studied Electrical Engineering at RWTH in Aachen (Germany) and holds also a degree „Master of Engineering“ of Purdue University (Indiana, USA). He received his doctorate degree in 1988 based on a thesis on methods for „Monitoring and Charge Control of Batteries in Electric Vehicles“ from RWTH Aachen.

From 1989 to 2004 (from 1991 on as senior manager) he worked in the field of „Actuators and Mechatronics“ as well as new automotive power supply systems at Daimler Research in Frankfurt. From 2004 on he was heading the development of testing methods for chassis and assistance systems as well as setting up test vehicles in Sindelfingen; from 2012 to 2017 he also was head of the Driving Simulation Center of Daimler AG.

Dr. Schöner played a key role in defining the ongoing German government-funded research project PEGASUS, with the goal to define „How good is good enough? And how can we prove this?“ with respect to the driving task of AV, http://www.pegasus-projekt.info/en/home.