ArchitectECA2030

SC 1 Demo 1.3 Key Card

Simulation of run-time monitoring device for automated driving and robust environmental perception

Main aim

This demonstrator focuses on reliable and robust environmental perception systems for automated driving and aims to develop the first implementation of a MonDev concept on a complete automated driving system level. This requires the implementation of sensor models in a simulation framework which allows the modelling of sensor faults to analyse the effect of such faults on the automated driving system performance as well as the assessment of the MonDev concept.

Partner	*VIF*
ECS value chain	*OEM / Tier-1*

State-of-the-art	Beyond SotA / Innovation	Targeted TRL
• *No unified framework for run-time risk assessment on the overall automated driving system level* • *Co-simulation using specific tools depending on specific requirements* • *Emergence of simulation as a key element of XiL testing and virtual Homologation*	• *Use of redundant sensor configurations for perception sensors* • *Use of component and sub-system level quality metrics as a source of risk assessment* • *Demonstration of the overall concept for risk assessment and monitoring functionality on the whole automated driving system level*	*Level 4*

Link to project objectives

Objective	***Addressed (Y/N)***	***How***
O1 – Continuous robust design optimization for each part in the ECS value chain	*Y*	*Continuous robust design optimization of the **environment perception system** (sensor fusion) feeding the ACC and LKA driving functions to improve their main behavior competences including all layers (SC: Radar Sensor Controller -> **C: Radar Sensor -> SS: Perception System (Sensor Fusion) -> SS: ACC/LKA behavior competence -> S: vehicle**)*
O2 – Framework for safety validation of ECS value chain	*Y*	*The combination of the two developed safety validation frameworks (**first: addressing the needs of S, SS and C layers** and second: specific needs of the SC layer) cover the entire ECS value chain.*
O3 – Identification & management of residual risks over the entire ECS value chain	*Y*	*Identification and management of residual risks on SC (Radar Sensor Controller) and C (Radar sensor) level -> **management of the residual risks on SS (Perception System - Sensor Fusion) and S level (reduced ODD and behavior competences of the ECA vehicle).***
O4 – End-user acceptance by trustworthy ECS value chain	*Y*	*Improved ADAS/AD robustness and fault tolerance by using redundancies and monitoring device thereby reducing driver handovers.*
O5 – Zero emissions, zero crashes, zero congestions by ECA2030-car	*Y*	*Improved reliability of the ADAS/AD Systems reducing accidents caused by human error (approx. %90 of the accidents).*

Joint demonstrator (JDEM1)					**Linked supply chains (Y/N)**		**Considered MonDev layers**	
DEM1.2	**DEM1.3**	**DEM4.1**	**DEM4.2**	**DEM4.4**	**SC1**	Y	**System (S)**	Y
					SC2	N	***Subsystem (SS)***	*Y*
					SC3	N	***Component (C)***	*Y*
					SC4	Y	***Subcomponent (SC)***	*Y*

Setup

Demo 1.3 was developed by VIF, which utilizes the architecture and the building blocks indicated in Figure 1*. Here ADAS/AD functions comprise ACC and LKA driving functions implemented in the Autoware.AI software architecture. An important aspect of the demonstration is the use of multiple sensors for each driving function and the use of sensor models (shown in* Figure 2*) which would allow injection of a number failure types as indicated in* Table 1.

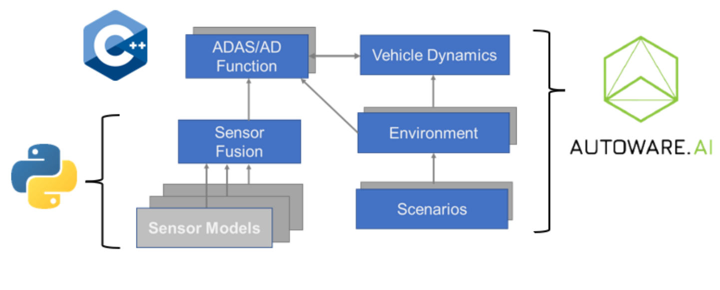

Figure 1: Simulation Framework with Building Blocks

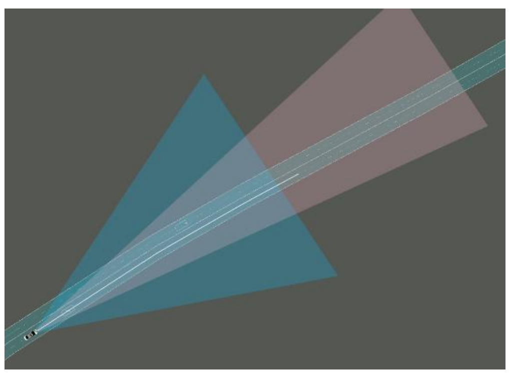

Figure 2: Multi-modal sensor modeling

Table 1: Effect of sensor faults with respect to different indicators

Indicator	Value	Effect
Sensor health	0	Normal
	1	No sensor output
Data quality	0	std is 0.1 [m] and 1.0 [m] in x, y direction
	1	std is 0.5 [m], 5.0 [m] in x, y direction
	2	std is 1.0 [m], 10.0 [m] in x, y direction
	3	std is 1.5 [m], 15.0 [m] in x, y direction
	4	std is 2.0 [m], 20.0 [m] in x, y direction
Drop-out	0	Time delay is 0 s
	1	Time delay is 0.3 s

Benchmark scenario/mission/etc.

Demo 1.3 implements use cases inspired by ACC/LKA testing and validation standards such as the ISO 15622:2018(E) and UN Regulation No. 157, where an example is shown in *Figure 3. Virtually injected failure into sensor signals as seen Figure 4 with potential accumulation into acceptable risk threshold as shown in Figure 5. This information can consequently be utilized to keep the driving function running or to initiate a minimum risk maneuver, which was demonstrated in the scope of Demo 1.3 in a virtual setting in conjunction with the Carla/Autoware.AI simulation environment as shown in Figure 6.*

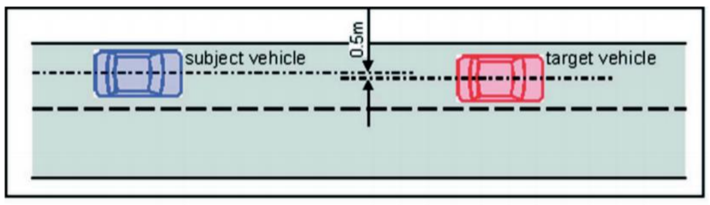

Figure 3: ACC automatic stop capability test ISO 15622:2018(E)

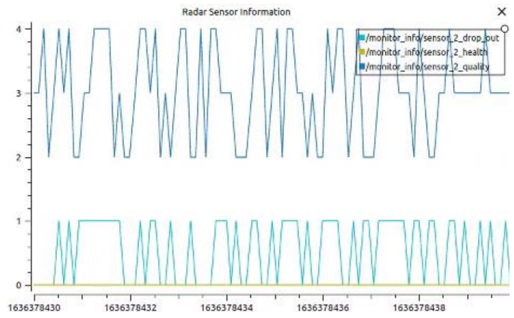

Figure 4: Failure injection on simulated sensor signals

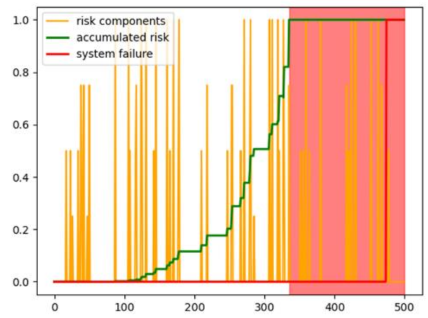

Figure 5: Risk accumulation in time

Figure 6: Simulation of the test scenarios in Carla environment simulation in conjunction with the Autoware.AI integration

KPIs (related to requirements)

KPIs which evaluate the success of the demonstrator in line with the stated requirements (WP1)

- *The time the driving function can operate despite the sensor errors*
- *Number of driver handover requests*
- *Driving function performance as compared to SotA systems*

Baseline

Baseline for KPIs

- *LKA & ACC typically work only with only one sensor without redundancy*
- *In most SAE Level-2 AD examples on the market, any sensor problem leads to an instantaneous driver handover*

Evaluation

Evaluation platform – simulation based on Autoware.AI (Architecture Proposal) Software Framework

Current status/demonstration

Results, plots, evaluated KPIs, meet requirements, videos, etc.

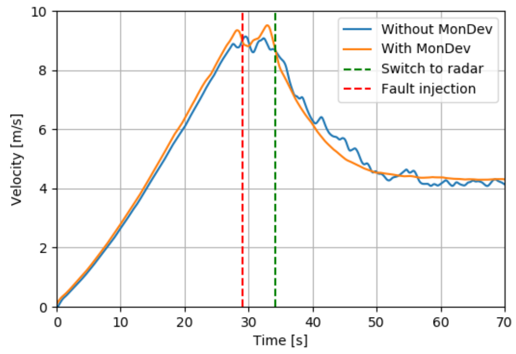

Figure 7: Switch from camera to radar as sensor source

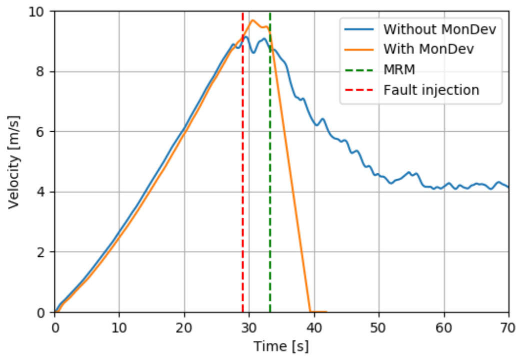

Figure 8: Initiation of a minimum risk manuever by the MonDev as a result of excessive risk accumulation due to failure injection

Next steps (timeline)

- *Dissemination of the results as conference and journal publications*
- *Analysis and potential extension of the risk assessment methodology beyond TRL 4*
- *Further utilization in other research projects*

Impact

Monitoring of the ADAS function behavior subjected to sensor anomalies and signal degradation and demonstration of a MonDev concept on the overall automated driving system level in a virtual setting.

Used standards

- *SAE-J3016 ; SAE-J3018 ; SAE J3088*
- *ISO 11270 ; ISO 17361 ; ISO 17387 ; ISO 26262*
- *UNECE/TRANS/WP.29/2020/81*
- *ISO/PAS 21448*

These standards are the international norms relevant to the developed driving functions. The functional conformity to the related standards is outside the scope of the project. These serve only reference purposes.

Future standardization potentials

- *Virtual testing and homologation of ADAS/AD Systems*
- *Having redundant or multi-model sensor configurations as an "object and event detection and response" (OEDR) requirement for improved functional safety of ADAS/AD systems*
- *MonDev as an integral part of the automated driving software stack to monitor the runtime system behaviour of the system*

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