Reduce Development Time with Next Generation DIL Test with Sensors for ADAS/AD Functionality Performance Verification and Optimization

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Abstract

Driver in the Loop (DIL) test is a proven methodology to verify embedded software performance in automotive controllers with human input. Adding sensors to the DIL test further narrows the gap with ground truthing and the costly system update iterations that follow and enables a higher degree of reproducibility and repeatability tests to quickly optimize on feature performance for Automated Driver Assistance Systems (ADAS) and Autonomous Driving (AD).

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1 The Challenge

As ADAS and AD capability races towards reality, the challenge of validating such capability and testing relevant sub-systems adequately to ensure vehicle-level feature performance continues to persist. A key stumbling block continues to be the large differences between lab tests and ground truthing data which often results in lengthy iterative improvements to ensure desired performance and reliability.

2 The Solution

A potential solution is to include sensors in the DIL test to further replicate the real-world driving use case for the vehicle. By stimulating the sensors according to the scene generation in progress, the DIL test now includes the sensor and

ADAS/AD sub-system into the loop for a closer experience towards a VIL test and a test drive. This approach can be applied for radar, lidar, and camera sensors for ADAS/AD capability as well as V2X and GNSS for vehicle connectivity.

3 Traditional Approach: HIL and DIL for ECU software verification leading to VIL

While Hardware in the Loop (HIL) test focuses on ECU software verification through ECUs running in a loop with modelling and simulation of vehicle dynamics, sub-systems and external drive scenarios, DIL test introduces the human interaction as an additional test vector to gauge reliability of features and assurance of the sub-systems operating together per requirements. And then heading to a Vehicle in the loop (VIL) test to confirm system and feature performance before a drive test.

4 Our Approach: Sensor Fusion for HIL and DIL leading to VIL

Together with our collaborators, InnoSimulation, S.E.A. Datentechnik GmbH, and National Instruments, our approach focuses on including sensors earlier into the software testing processes for HIL and DIL tests for ADAS ECUs and/or central ECUs. At the Automotive Testing Expo 2018 in Shanghai, our team demonstrated DIL with camera and radar sensors including GPS positioning and V2X concepts running off a SCANeR Studio™ simulation.

Figure 1: DIL with Sensor Fusion at Automotive Testing Expo 2018 in Shanghai. A collaborative concept demonstration by National Instruments, InnoSimulation, S.E.A. Datentechnik GmbH , and Konrad Technologies.

5 Technology Overview: DIL with Sensor Fusion

As shown on the image below, the capability demonstrates how a Compact Driving Simulator (CDS) from InnoSimulation running with a SCANeR Studio™ vehicle dynamics and scene generator simulator to test ADAS software on an NVIDIA PX2 controller is outfitted with a camera and radar sensor. To close the loop, a camera simulator from InnoSimulation and a radar simulator from Konrad Technologies are added to the loop. Object streams are output from the SCANeR

Studio™ drive simulation and treated as an input stream by the camera and radar simulators.

Figure 2: Compact Driving Simulator (CDS) from Innosimulation with the nVidia PX2 on its right and the Konrad Radar Object Simulator with GNSS and V2X simulators on the left.

The Konrad Technologies Vehicle Radar Test System (KT-VRTS) is built on the National Instruments VRTS and implements the target simulation according to the drive simulator CAN data stream. The NI VRTS uses a 76-81GHz NI mmWave Radio Head connected to a PXI Vector Signal Transceiver, a calibrated RF instrument, and an analog variable Delay Generator to implement sophisticated object simulation as an active simulator and calibrated RF measurements such as EIRP, occupied bandwidth, operating frequency, and chirp analysis.

A similar approach is used for the V2X simulation from S.E.A. Datentechnik GmbH that is built on the NI USRPRIO platform and with a CAN interface to communicate by the simulated signals that are closely synchronized to close the loop. This platform currently supports 802.11p (DSRC) and LTE-V (c-V2X). The unique implementation of the 802.11/LTE-V communication using the NI Software Defined Radio technology provides the unique ability to provide V2X communication, detailed monitoring, deep level fault injection and high-load V2X simulation (congestion).

As shown in the diagram below, the system uses the API and RTGateway provided by the simulation software SCANeR Studio™ installed in the INNOSIMULATION Compact Driving Simulator (CDS) to connect the external devices such as the driver input device (i.e. the CDS), the actual camera, the ECU (NVIDIA Drive PX2) equipped with ADAS logic, the actual radar sensor test simulator (VRTS) and GNSS simulator. This is an example of configuring DILS and HILS by connecting devices.

As shown in the block diagram, PX2 (with sample ADAS logic in the ECU) uses deep learning-based real-time recognition (Lane Detection, Pedestrian Detection, Object Detection) and rule-based path planning using the input image data from the camera installed in CDS and real radar sensor data output from VRTS. And the control result (steering and go/stop) is reflected in simulation software

(SCANeR Studio™) to enable the ADAS logic test in the virtual driving environment.

The simulation software SCANeR Studio™ generates various challenging conditions such as weather, road and traffic situations, provides an automated virtual driving test environment, and all the data of the simulation is provided in various formats for datalogging to enable post-data analysis after logging.

In addition, 3D roads based on actual GPS data can be linked with various real-time traffic simulations and provide a basis for various experiments and tests based on V2X.

The Compact Driving Simulator (CDS) is built using actual vehicle components and offers a high-performance force-feedback steering wheel with real-time control and a wide range of programmable operator controls.

In other words, the CDS is able to fully provide the various driver experience environments required for autonomous vehicles, manual driving, autonomous driving, as well as various Driver Monitor System (DMS) tests.

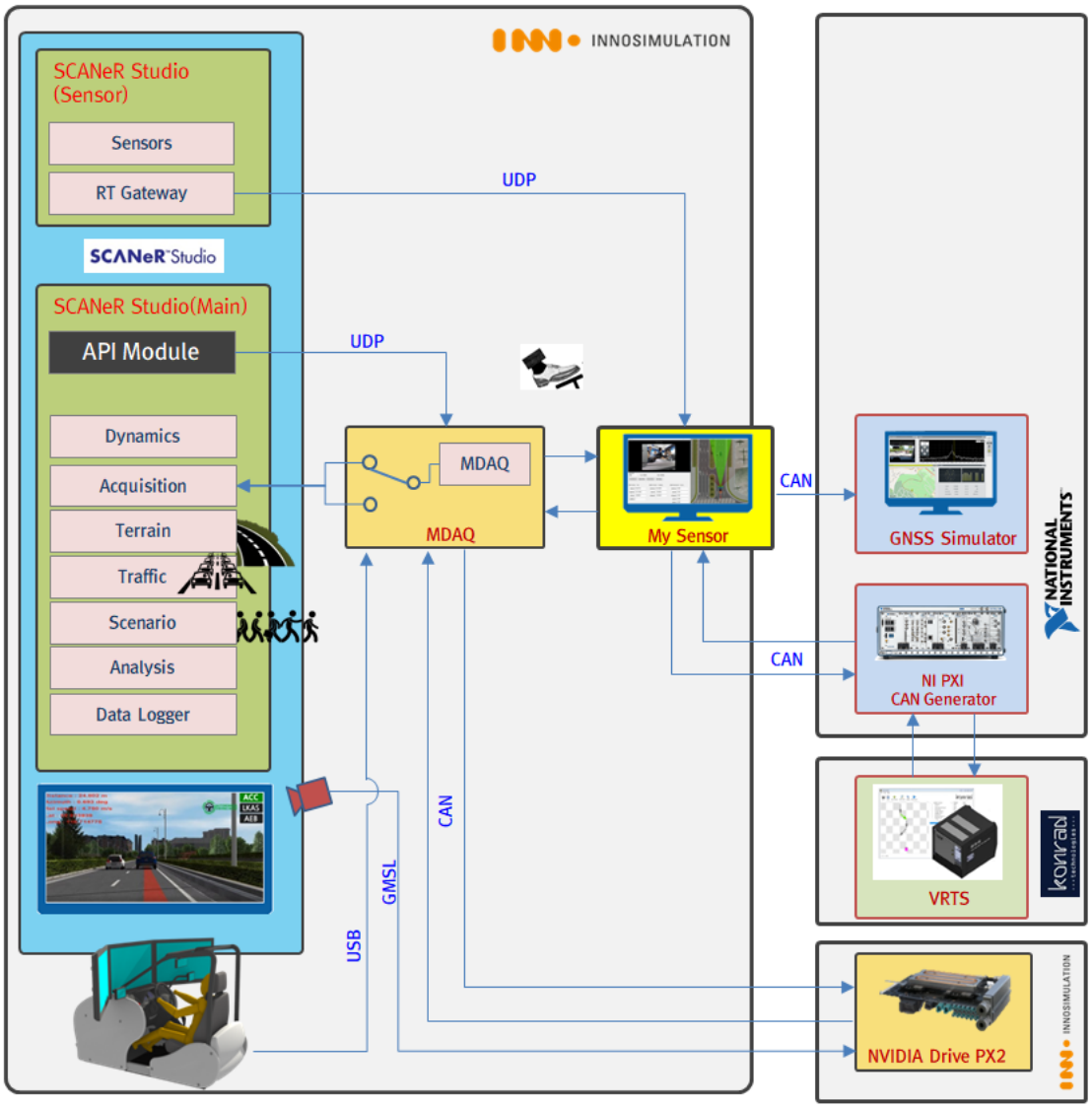

Diagram 1. Architecture Diagram of Driver in the Loop with Sensor Fusion Demonstration System

6 Solution Benefits: Reduce your software validation time with Sensor Fusion DIL Test

- With Sensor Fusion DIL test, users can perform sensor functional test, ADAS/AD sub-system functional test, and ADAS/AD ECU software verification with a single test application to apply learnings and optimize on ADAS/AD functional test and development.
- This technology also enables sophisticated Gage R&R procedures to be implemented in the lab to verify ADAS/AD ECU performance according to rigorous standards and conditions similar to actual driving use cases.
- While iterative testing and improvement is a current status quo for ECU test protocols, a scalable platform that can perform HIL and DIL test and then include the sensors for further testing will reduce the iterations due to the higher quality of testing involved.
- Another critical step in testing ADAS/AD and autonomous vehicle systems revolves around synchronization. One flexible and scalable platform that generates different data stream is vital, while also being capable of running a real-time operating system for deterministic simulation of the world around the system.

This white paper is jointly written by National Instruments, InnoSimulation, S.E.A. Datentechnik GmbH and Konrad Technologies.

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About Konrad Technologies

Since 1993, Konrad Technologies (www.konrad-technologies.com) has successfully developed, designed and integrated customer-specific test solutions providing customers with R&D, qualification and manufacturing of electronic products with tools to fulfill their quality goals, accelerate engineering and development throughput.

Customers in a wide range of industries from Automotive, Aerospace and Defense, Wireless Communications, Consumer Electronics, Medical, Semiconductor, General Electronic Manufacturing to Industrial Automation use KT's integrated hardware and software platform based solutions to improve their performance worldwide.

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ADAS iiT consortium (ADAS Innovation in Test)

ADAS iiT (www.adas-iit.com) is an amalgamation of four National Instruments partner companies (Konrad Technologies GmbH, SET GmbH, S.E.A. Datentechnik GmbH and measX GmbH & Co. KG) formed with the goal of making autonomous driving even safer. Founded in March 2017, the ADAS iiT group offers a complete test of fully autonomous vehicles in a virtual environment, delivering ADAS turnkey, end-to-end solutions from one single source.

About National Instruments (NI)

NI (ni.com)is a provider of platform-based systems that enable engineers and scientists to solve the world's greatest engineering challenges. The Alliance Partner Network is a program of more than 1000 companies worldwide who provide complete solutions and high-quality products to the user based on graphical system design. From products to systems to integration to consulting and training services, Alliance Partners are uniquely equipped and skilled to help solve some of the toughest engineering projects.

About InnoSimulation

InnoSimulation was founded in 2000 by a group of research staff at the Graduate School of Automotive Engineering of Kookmin University, Korea. We are an innovative and dynamic company, built on extensive expertise in the areas of design, development, validation and application of various simulation systems and vehicle electronic control systems. InnoSimulation delivers complete solutions for R&D driving simulators, training simulators, electric motion platforms, vehicle control systems and telematics.
Our worldwide customers include automotive companies, universities, research institutions and driving schools. We continue to develop state-of-the-art technology and solutions by working closely with university and industry partners. We strive to provide our customers with the most advanced technical solutions.

About S.E.A. GmbH

S.E.A. offers test and measurement solutions since more than 25 years. We develop test software, measurement equipment, and turn key systems which base on our own products and our developers know how in various fields. Wireless communication is one focus of S.E.A. Our excellence is to provide you customized solutions from one source. This includes all services starting with conceptual design and development to project

execution up to maintenance of software and hardware. Our industry solutions are based on the technical and scientific knowhow of our personnel and a trustful relation with our customers.

Please use our free download offers to test our software tools for developers and inform about our support offers. We would be pleased to meet you in our head office in Troisdorf near Cologne/Germany.

S.E.A. is National Instruments Alliance Partner and offers NI certified products.

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