17. Newsletter
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Technische Hochschule Ingolstadt

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FORSCHUNG AN FACHHOCHSCHUL

Dear Ladies and Gentlemen, Dear Colleagues,

we are very pleased to present you today our 17th SAFIR Newsletter and hope you enjoy reading it.

You can also find all previous newsletter issues for download on our website www.thi.de/go/safir in the "Newsletter" section. There you can also view the data protection information. If other colleagues or partners of yours would like to receive our newsletter automatically in the future, please contact Camila Heller by e-mail, at camila.heller@thi.de.

Our newsletter aims to provide you with regular updates on news, current topics and dates of interest relating to the SAFIR research partnership. We look forward to your feedback as well as constructive suggestions and requests for changes!

With best regards from the entire

SAFIR team

SAFIR Management

- ***SAFIR Network Meeting - Safe Sustainable Mobility***

We would like to invite you to this year's SAFIR network meeting with the topic "Safe Sustainable Mobility".

The event is scheduled for Friday, November 24 th, 2023, commencing at 9 a.m. and will be hosted at Technische Hochschule Ingolstadt.

The SAFIR research partnership is also increasingly concerned with vehicle safety in the context of new, sustainable mobility concepts.

How can sustainability be anchored as an essential goal of our time in future mobility? We want to address this and other questions at our networking event.

SAVE THE DATE: Make a note of the date in your calendar - you will receive further information and more detailed content in the coming weeks. Feel free to forward or share the event.

- ***Presentation of the Impulse Project 12: Functionalsafety for Automotive Objekt Recognition of Optical sensors by state monitoring of CameRAs (AURORA)***#

Vehicle sensors, crucial for safety-relevant environment detection, degrade over time. The AURORA project, led by Prof. Elger, is cantered on Predictive Health Monitoring to anticipate this degradation, ensuring enhanced safety. Car2X communication, a pivotal feature, provides comprehensive data, both internal and external. The project's ambition is not only to refine the SelfX diagnostic function but also to use advanced machine learning algorithms. These algorithms are designed to identify potential sensor malfunctions early, further safeguarding vehicular operations.#

WP1 and WP2: Development of Monitoring Systems for Lens and Optical Modules#

A comprehensive measurement system is in development, encompassing both lens condition and optical module monitoring. These systems are designed to track key indicators, covering aspects like sharpness and aberrations, especially under temperature changes in aged components. Based on the data generated in these work packages WP4 will train an algorithm to predict remaining useful life (RUL) of lenses and optic modules.#

WP3 Influence of Camera Properties on Object Detection#

This package investigates the influence of camera condition on image defocusing and object detection. Optical simulations are conducted in a DOE study and the corresponding effect or state of the art object detection algorithm is tested on these simulated images. A validation study is performed moving the lens on the optical axis to emulate defocus in the system and capturing scenarios involving vulnerable road users.#

WP4 Condition Monitoring of Optical Modules#

An algorithm will be developed which assesses the optic module's condition based on data from WP1 and WP2. The key indicators of lenses and optical modules determine their health and RUL.#

WP5 Assembly of the Lens and Lens Holder PCB Package#

A mounting system connects a lens and its associated Imager-PCB package using passive optical alignment. The lens aligns with a hexapod and attaches to the package. This helps develop simplified assembly process for optic modules.#

WP6 Field Sharpness Monitoring#

Optical modules from work package 3.2.5 will be integrated into a research vehicle. These modules will be continuously read out, with data transferred to a cloud. Using this data and algorithms, key indicators will be determined. Machine learning algorithms from WP4 trained for safety-relevant metrics would evaluate the optic module health.#

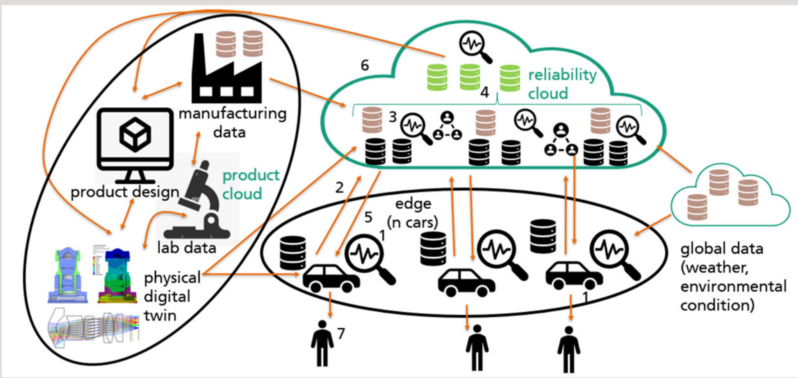

Figure 1: Based on lab data a "0 lifetime model" is installed on vehicles which assesses state of sensors based on health indicators. This data is sent to "reliability cloud" where a trained algorithm detects anomaly and estimates lifetime "1 model". Relevant data is

extracted and used in the training data pool replacing the "0 model" with the "1 model". Failure and lifetime data is shared with OEM and manufacturer for improvement and also shared with the vehicle user. Lifetime model is periodically trained and updated as "n-model". Quelle: THI

Research assistant in the AURORA project

Amit Pandey graduated with a master's degree in Automotive Engineering from Technische Hochschule in Ingolstadt in 2020. He has worked in the field of FEM and physical simulations previously. He is a researcher at the Institute of Innovative Mobility and currently he works in the research group of Prof. Gordon Elger and his focus is state monitoring of automotive cameras.

Funding reference number AURORA: 13FH7I12IA

- ## *News from Impulse Project 13: Hybrid Models and AI Methods for Safe Mobility - Data Usage for Securing Automated Driving Functions (HyMne2)*

The Impulse Project 13HyMne2 is the successor project of Impulse Project 8, HyMne. The results of the predecessor project have shown that the combination of domain knowledge and machine learning is very beneficial to generate highly accurate navigation correction data, to create realistic driver behavior from data-based models as well as to generate test scenarios for testing automated driving functions. The HyMne2 project continues the research on hybrid AI methods with the goal of demonstrating the benefits of these methods in applications. This includes the detection of error patterns in navigation correction data, guidance mechanisms for the generation of realistic driver behavior models, and the selection of relevant traffic scenarios for testing automated driving functions. With this newsletter we would like to introduce the SAFIR Impulse Project 13, which is led by Professor Dr.-Ing. Michael Botsch. It consists of three subprojects, which are presented below.

AI-based optimization of correction data for inertial measurement systems

Even with the availability of simulation environments, the research and development of automated driving functions require validation with real tests, which in turn require a highly accurate vehicle state that can be used as a reference. This reference state is estimated by means of Inertial Navigation Systems (INS), which use sensor fusion methods to fuse the measurements from accelerometers and gyroscopes with correction data from various types of external sensors. The focus of the first subproject is the detection of error patterns in the correction data for inertial navigation, because when the correction data is faulty, the accuracy of the reference state is negatively affected. To this end, AI methods will be combined with domain knowledge from the field of vehicle dynamics to extract navigation correction data from on-board sensors and recognize when this correction data is faulty. The goal of this subproject is to explore methods that allow 1) estimating a highly accurate vehicle state from INS and on-board sensors. The focus is on AI-based error pattern recognition; 2) to plausibilize correction data generated from on-board sensors; 3) to evaluate the accuracy of the navigation solution when using correction data from on-board sensors.

The industry project partner in the subproject I is the company GeneSys Elektronik GmbH, and the INS of the industry partner that is used is called ADMA.

Figure 2: Test vehicle equipped with an ADMA G-Pro+, a Correvit S-Motion and a Car-PC. Source: THI

Guided Driver Behavior Generation

The focus in the subproject II is the conditioning of AI methods for the generation of specific driver behavior models that can be used in simulation environments. To this end, the strengths of data-driven and rule-based approaches are combined. While a data-driven model developed in the Impulse project 8 already has the ability to generate realistic trajectories, these are completely deterministic and cannot be adapted. Rule-based models that built on domain knowledge offer more flexibility here but htey are not able to learn naturalistic driver behavior models from the data.

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Figure 3: Architecture of a data-based model for learning driver behavior. Source: THI

In the subproject, generative AI models are used, in particular diffusion models. The goal is to generate non-deterministic, i. e., adaptable and variable, trajectories. Through the integration of a suitable guidance mechanism, it will be possible to better control the trajectory generation and to obtain flexible, realistic driver models.

The industry project partner in this subproject is the company ZF Mobility Solutions GmbH.

Selection of relevant scenarios for the validation of driving functions

As a result of the increasing complexity of autonomous driving functions, the amount of testing required for validation will rise sharply in the future. In order to keep the so-called "road kilometers" within a manageable range, a large part of the vehicle tests must be performed in virtual environments. Characteristic test scenarios are necessary for this. However, these are strongly dependent on the operating point of the driving function to be considered. In the third subproject, AI methods and domain knowledge from publicly available data sets such as Lyft, Argoverse, or INTERACTION, as well as from the scenarios generated in the predecessor project HyMne, will be used to identify relevant test cases that are either highly critical or in which road users show untypical driving behavior. The subproject focuses on suitable architectures that combine AI and domain knowledge to realize the identification and selection of test cases. Furthermore, it should be explored whether the considered methods can contribute to the identification of the Operation Phase Activities according to ISO21448. Based on real tests at the outdoor facility of CARISSMA, the subproject will analyze the deviations between the virtually determined "corner cases" and the corresponding real driving tests. The results will be used to improve the specification of the corner cases.

The industrial project partner in this subproject is Audi AG.

Figure 4: Representation of the outdoor facility of CARISSMA in the simulation environment CARLA. Source: THI

Funding reference number HyMne 2: 13FH7I13IA

Research assistant in the HyMne2 project#

Robin Egolf graduated from Technische Hochschule Ingolstadt with a Bachelor's degree in Artificial Intelligence in early 2023, and is currently continuing his education in a research master's program. Already in his first bachelor semester he worked as a working student assistant in the research group of Prof. Botsch, where he is now a research assistant within HyMne2. In his research work so far, he has focused on the use of generative AI models in the field of automated driving.#

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