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Digital Twins in the Automotive IT of the Future

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Picture: SofDCar-Project Consortium, 2023

Content

- State-of-the Art
- What is a Digital Twin and what is its relation to vehicles?
- Example of a Research Projects
- Conclusion



What is a Digital Twin?



"The Digital Twin is a virtual representation of a physical asset ... capable of mirroring its static and dynamic characteristics."

A Digital Twin:

- contains and maps various models of a physical asset, of which some are executable, called simulation models.
- communicate with each other and can exchange data and information
- Digital Twin can be made available throughout the entire lifecycle of the product

An Asset:

- can be an entity that already exists in the real world or
- can be a representation of a future entity



According to: Ashtari Talkhestani, Behrang, Jung, Tobias, Lindemann, Benjamin, Sahlab, Nada, Jazdi, Nasser, Schloegl, Wolfgang and Weyrich, Michael. "An architecture of an Intelligent Digital Twin in a Cyber-Physical Production System" at - Automatisierungstechnik, vol. 67, no. 9, 2019, pp. 762-782. https://doi.org/10.1515/auto-2019-0039

From the Vehicle Operating Systems to the Backend





Software and Data provide new Functions and Services

Today the race towards a new digital Ecosystem is on: The architecture of the future has to be in line with the "big business" strategy of the top players.



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There are lots of Ideas for IT in Automotive and Mobility

The race for "new smart and connected" functionality in cars and automotive infrastructure is on. Hundreds of Startups are creating innovative ideas about smart future mobility.



For instance: More that 100 Startups and 3600 visitors during the EcoMotion week 2023 in Tel Aviv hunting for innovative ideas in IT, software and services for mobility



Jeff Brandes, (ex-) Governor of Florida: "Only those will achieve who are managing to combine the technological development with a business model"

Statistica on Companies in the field of Automotive-IT

Analysis of the EcoMotion Exhibition 2023 (IL), CES 2023 (USA) and IAA 2024 (D)



Overview of Technology fields





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Software-defined Vehicles (SofDCar lead project)

SofDCar consortium addresses the challenges of future E/E and software architecture in vehicles.

- Vehicles are considered as part of a **network of all vehicles and infrastructure**
- **Digital twins** based on efficient data structures form a virtual image of the physical vehicles
- A **data loop** enables a connection between the vehicle in operation and development, e.g. for the re-deployment of software.





Research Topic: Digital Twin

How to build and deploy a Digital Twin?



Improved environmental detection

Extension of the sensor acquisition range through data exchange



Anomaly detection

Configuring the most appropriate Al-based anomaly detection methods depending on the context.





Semantic integration of digital twins

Linking of different models for different aspects of a digital twin of an automobile and exchange of information between these different models

Research Topic: Re-Deployment

How can CI/CD approaches be deployed for the Vehicles?



Development of variant-rich software for the softwaredefined vehicle

Intelligent complexity management of variant-rich software, considering the wide range of customer requirements



Over-the-air update for vehicle fleets

Updating entire fleets of vehicles Over-the-Air while considering the role of cloud elasticity due to different workloads





Orchestration of vehicle components

Variant modeling of deployment models with the goal of orchestrating software and hardware in the vehicle and the cloud (install, configure, and update)

Research Topic: Data Loop

How can Data be exchanged and stored?





Data stream and update analysis

Continuous analysis of the 5G architecture for a dynamic error management and as feedback for future software updates



Federated learning for improved connectivity and privacy

Training of machine learning models with decentralized data in vehicles by avoiding the disclosure of personal information and improving connectivity



Privacy

Anonymization and policies to protect the privacy of the drivers, which is guaranteed by the operation of the pipelines.

Research Topic: Demonstrator

How to investigate on real world scenarios?



Event-based communication of vehicles

Exchange of information between vehicles in order to coordinate an overtaking process (cooperative overtaking) and carry it out autonomously



Test bench integration

Integration of the vehicle dynamics test bench and the Stuttgart driving simulator into a 5G environment





Multi-agent systems smart infrastructure

A highly connected smart infrastructure with vehicles that communicate with the infrastructure to use location-based and decentralized services while respecting privacy requirements

Status of the Testbeds 1 and 2 (as per October 2023)

Allocated budget is freed, call for tender process about to be started:

- Public 5G net of German telecoms along with advance functionality (e.g. positioning, edge services) to be available autumn / winter 2023
- Cockpit installation about to be purchased but require significand E/E integration effort to be ready for tests
- Private 5G net with edge core and mobile test installations are still stuck in release processes of funding organization





Conclusion: There are many questions ...



Here are some examples, but there are many more facets with lots of depth.



 How can topics of cooperative perception of connected vehicles be utilized?



 How can future function be based on a Digital Twin and deploy techniques of modelling, synchronization, real-time processing etc.?



• What are the issues of software product lines and software erosion in the upcoming software systems, which rely on CI/CD toolchain?



• What are the "real world" problems and issues such as latencies, different formats, open source framework limitations etc.?