PAVE360 for Overcoming the Billion Driven-Miles Challenge of Autonomous Vehicles

CIMdata Highlight

Waymo announced, on July 10, 2019, at the *TechCrunch Sessions: Mobility 2019*[1] conference that it has driven autonomous vehicles (AVs) over 10 billion miles in simulation and over 10 million miles in the real world. In Waymo's experience, the relationship between the number of miles driven in simulation and those driven in the real-world is a function of the capability and maturity of the autonomous system. The more advanced the autonomous driving system, the more driven-miles are needed to focus on edge cases and advanced navigation design. Additionally, as real-world driven-miles are accumulated the sophistication of simulation increases, helping increase the reliability of virtual testing. Essentially, fidelity and scale are the two interconnected must-haves for leveraging simulation to conquer the challenge of the billions of driven-miles faced by AV developers.

On May 10, 2019, Siemens Digital Industries Software (Siemens) introduced PAVE360™, a pre-silicon autonomous validation environment to accelerate the development of innovative platforms for verification and validation of the artificial intelligence (AI) capability built into AVs. PAVE360 allows an efficient integration of automotive hardware (HW) and software (SW) sub-systems, full vehicle models, sensor models, sensor data fusion, vehicle driving environment models, and traffic movement models including vehicle-to-vehicle, vehicle-to-infrastructure, and vehicle-to-pedestrian (V2X) communication. With PAVE360, it is possible to simulate the driven-miles for all achievable levels of vehicle automation by exercising the digital twin of the vehicle within the digital twin of the driving environment, as well as the virtual model of the system-on-chip (SoC) that controls all aspects of vehicle performance including autonomous driving. This is foundational for achieving the billions of driven-miles similar to what Waymo has achieved through its proprietary simulation and integration solutions.

At a meeting with CIMdata, Mr. David Fritz, Global Technology Manager of Autonomous and ADAS at Siemens described three key concepts of PAVE360.

1. "Correct operation of an automated vehicle can only be determined in the context of the entire vehicle and the environment within which it is operating."
2. "Constrained random testing cannot guarantee coverage. Corner cases not possible to test with physical platforms require correlation between virtual and physical models."
3. "Consolidation of functionality is inevitable and will follow the path of other industries that have gone through similar transformations."

The PAVE360 platform uses Siemens applications Simcenter Prescan, Simcenter Amesim, and Volcano (Autosar) for realistic sensor data acquisition, traffic and hazard scenarios, and physics-based vehicle response to road conditions and maneuvers. Additionally, the PAVE360 platform uses Veloce Fault App, Catapult HLS, Simcenter Prescan, Simcenter Amesim, and Mentor Safe IC for system safety and reliability design by proving fault tolerance with repeated closed-loop scenarios and random SW-related faults. The crucial element of PAVE360 for modeling the digital ICs is Siemens' Veloce emulator, which is a signal-accurate HW computing platform that runs 1,000 times faster than a SW simulator on a general-purpose computer. Siemens highlighted the three concepts of PAVE360 through a demonstration of rapid SoC design changes based directly on the demands of changing road hazard and traffic scenarios.

[1] Waymo has now driven 10 billion autonomous miles in simulation, *TechCrunch Sessions: Mobility 2019*

The demo leveraged a vehicle system model that includes sensing and actuation and vehicle dynamic performance within the driving environment.

Finally, Siemens PAVE360 is a validation environment that brings together disparate simulation systems from Siemens and other vendors leveraging the electronic design automation (EDA) expertise from Mentor that was used to developed purpose-built silicon, the Veloce emulator, necessary for automakers to run large-scale, high-fidelity simulations. PAVE360 can scale hundreds of simulations to cover millions of traffic conflict and road hazard scenarios, and consequently help accelerate the efforts of automotive OEMs and suppliers to attain Waymo-like maturity in AV development.

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