Innovative Motion Cueing enabling a Realistic Simulator Experience of Future Vehicle Behavior

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Abstract

Automotive OEMs are increasingly evaluating active safety and autonomous driving functionality in a virtual environment, since this enables a safe and efficient procedure for optimizing the vehicle active safety and driving behaviour. Driving simulators offer a next step by putting the human in the virtual loop, so he/she can experience the behaviour of the vehicle. The Simcenter® simulation software of Siemens PLM enables the integration of a high-fidelity digital twin of a vehicle in driving simulators to support a better evaluation of its ride comfort and handling qualities before it is built. Typical driving simulators provide the driver with a visualization of a virtual environment and steering wheel, pedals and other human-machine interfaces to interact with the vehicle. The vehicle sound also increases the fidelity of the simulator together with an active control of the steering wheel. Nevertheless, in order to reach a higher level of driving feeling, the addition of inertial or motion cue is crucial – that is, the motion of the simulator that aims at reproducing the motion of the real vehicle.

Driving simulators use dedicated motion systems to provide inertial cue. These motion systems typically have a much smaller range of motion as compared to the large motion range of a real vehicle. For this reason, the accelerations perceived by the driver in a real car cannot be reproduced one-to-one on a simulator. A trade-off must be made using dedicated control algorithms known as Motion Cueing Algorithms (MCAs).

Different MCAs have been developed in the last decades, one of the most commonly adopted is known as Classical MCA. The Classical MCA is based on filters, where linear accelerations and angular velocities resulting from the vehicle dynamics simulation are first scaled and then high-pass filtered to remove constant signal content (washout). In addition, low-pass filters are used for longitudinal and lateral accelerations, where the motion system is tilted to use the gravitational acceleration to reproduce the sustained accelerations. The simplicity of the Classical MCA has facilitate its spreading, but at the same time presents some limitations in the necessary tuning to adapt the algorithm to a specific motion system, in order to guarantee that the computed solution remains within the motion system physical limitations.

More recently, an optimization approach has been adopted for MCAs, where the Model Predictive Control (MPC) technique is used to compute an optimal solution to reproduce as accurately as possible the target vehicle motion, while considering the physical limitations of the motion system. This new approach has shown multiple advantages as compared to the Classical MCA, but it requires a higher computational effort. Another aspect to consider is that the optimization-based MCA requires future knowledge of the vehicle motion to reproduce on the simulator, this motion is needed as a reference to optimize the simulator motion within its constraints. These limitations restrict the application of this MCA to passive driving simulations, where the motion to reproduce on the simulator is fully known a priori and it can be optimized in advance.

It will be shown in this pitch talk that the improvement and adoption of advanced MCAs in motion driving simulators provides a more realistic driving feelings, which enables a better subjective validation of active safety systems and autonomous driving functionalities for the design of future vehicles. The driving simulator is located at Siemens Industry Software NV in Leuven; it enables evaluating realistic driving scenarios such as optimization of ADAS functionality and pedestrian crossing.

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