Optimum Utilization of a Motion System by Offline Motion Cueing and its Applications

Sebastian Granzow

BMW Group Research and Technology, 80788 Munich, Germany
sebastian.granzow@bmw.de

In the driving simulation of BMW Group Research and Technology the requirements of the application field vehicle dynamics are increasing. In a simulator with motion base dynamics variables for different vehicle types are evaluated on the basis of selected standardized maneuvers. An optimal evaluation requires an unmodified representation of movement. This requirement is contrary to the limited motion space of existing motion systems. For this reason an extension or redesign of classical motion cueing algorithms is necessary.

The purpose of a motion cueing algorithm is to transform accelerations of a vehicle into movements of a platform of a motion system. To achieve a realistic driving experience the complete motion space of the system needs to be used optimally. A pass through the limits of available space degrades the impression of movement and of driving.

The scaling of the vehicle accelerations as well as an integrated safety (buffer) and a superimposed drift back into the neutral center position (washout) avoid running against these limits. Thereby the unpredictable behavior of a driver, especially in the longitudinal dynamics is taken into account.

Usually, with these techniques the actual potential of the motion system is not completely exhausted. One way to solve this problem is to put the driver out of the loop (open loop), i.e. he cannot drive interactively, but experiences a predefined maneuver. The advantage is that over the entire time of this maneuver all accelerations are already known. Thus, either the maneuver can be integrated in the available movement space optimally (Maximum Scale) or it can be designed such that no scaling is required.

The evaluation of configurations in the chassis design takes place by the use of standardized maneuvers. Usually, they are created on software systems which are independent from the driving simulation software. The outcome of these software tools is the basis for the mentioned open loop driving simulation.

The objective is to provide the user a tool that can be used without having the knowledge of the motion cueing algorithm. Anyway, he must be able to achieve the optimum utilization of motion space of the simulator. The algorithm is controlled by the parameters of the implemented FIR filters with regard to the perception thresholds. In order to simplify the use of the Offline Motion Cueing (OMC), the algorithm is enhanced by an intelligent optimizer. This optimizer fits the maneuver perfectly into the motion envelope and additionally reduces the computing time.

Additionally, it considers the limits of movement space and the motion perception barriers while taking into account first the translational motion and then the rotary motion. It automatically checks whether a scaling of the movements is avoidable.

The application of the OMC Algorithm allows a significant increase of displayable maneuvers and of issues that could previously not be investigated. The simple application of the optimizer and the resulting possibilities of Offline Motion Cueing lead to a wide acceptance of the approach and respectively to many different applications.

This methodology is suitable for objectification of human perception barriers in terms of driving dynamics. In particular the knowledge of perception thresholds for certain maneuvers and driving conditions is important. It allows to identify and to scale degrees of freedom which are not important for the dynamics perception and the holistic impression of the maneuver.

The open loop mode, which is based on the presented Offline Motion Cueing Algorithm, comes along with some restrictions. Without modification test persons have no knowledge of important input variables like steering angle or accelerator pedal position. With the additional implementation of force feedback steering and accelerator pedal the driver experiences the input variables and performs a more extensive evaluation.

Further research and investigations have to be done to reinstate an interactive driver for a standardized driving dynamics maneuver. This needs a combination of algorithms from Classic and Offline Motion Cueing.