Motion cueing in driving simulation experiments

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The applicability of driving simulation to the real world is a crucial issue for vehicle design as well as human factors or road safety. Experimental data show that in full scale driving simulators longitudinal speed can be estimated correctly by the driver. Nevertheless, the role of vestibular cues in distance perception and steering is essential and has to be determined precisely for better applicability.

Motion cueing can be obtained by movement platforms controlled by a set of actuators mounted in a hexapod configuration, known as a Stewart Platform, used originally for flight simulation. It generates linear accelerations in the longitudinal and lateral direction, as well as roll, pitch and yaw angular accelerations in a limited workspace.

However driving simulation is more difficult in many aspects that flight simulation. The contact of the vehicle with a road of variable geometry and surface and driving in regards with the other vehicle of the road traffic are the most important of them. In addition, driving simulators have to be designed for non-professional drivers at significantly lower cost than in flight simulation.

Traditional hexapod motion platforms generate only limited displacements (up to approx. ± 1.5 m), though larger values are necessary to render transient accelerations. Maneuvers, such as breaking, changing lanes or entering, exiting bends, necessitate new innovative solutions in terms of both physical equipment and control-command algorithms, especially when cost is a critical factor.

While these developments are advancing today rapidly, the overall motion rendering fidelity has to be kept coherent. Humans accept a certain amount of variation in perceived vestibular linear and rotational amplitudes, allowing the use of a scale factor in the rendering of motion cueing. Nevertheless, the spatio-temporal integration of visual and kinesthetic cues are strongly relying on the overall simulator characteristics. For example, vestibular scale factors depend on the visual rendering quality as well as on the transport delays of the different rendering processes.

Thus, through the development of driving simulation techniques, psychophysical and human factors studies, as well as driving simulation engineering will lead to a more thorough understanding of human perception and control of self-motion.
References:


