Motion cueing in driving simulation experiments

Andras KEMENY

Renault – Technical Centre for Simulation
Vehicle Engineering Development
TCR AVA 2 12, 1 avenue du Golf, 78288 Guyancourt Cedex
e-mail: andras.kemeny@renault.com

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:

- Gibson, J.J. (1950) The Perception of the Visual World, Houghton Mifflin

- Rushton, S.K. and Salvucci, D.D. (2001) An egocentric account of the visual guidance of locomotion. Trends Cogn. Sci. 5, 6–7

- Nordmark, S. et al. (1984) Moving base driving simulator with wide angle visual system. SAE Technical Paper Series 845100,Warrendale, PA: Society of Automobile Engineers

- Reymond G., Kemeny A, Droulez J, Berthoz A. (2001) Role of lateral acceleration in curve driving: driver model and experiments on a real vehicle and a driving simulator. Hum. Factors 43, 483–495

- Drosdol, J. et al. (1985) The Daimler-Benz driving simulator, a tool for vehicle development. SAE Technical Paper. 940227 Warrendale, PA: Society of Automobile Engineers

- Panerai F., Droulez J., Kelada J-M., Kemeny A., Balligand E., Favre B. (2001) Speed and safety distance control in truck driving: comparison of simulation and real-world environment. Proc. Driving Simulation Conf. DSC 2001, Paris, France

- Boer, E.R. et al. (2000) Experiencing the same road twice: a driver comparison between simulation and reality. Proc. Driving Simul. Conf. Paris, France

- Kemeny, A. and Panerai, F. (2003) Evaluation perception in driving simulation experiments. Trends in Cognitive Sciences, 7(1):31-376

- Reymond, G. Droulez J, Kemeny A (2002) Visuovestibular perception of self-motion modeled as a dynamic optimization process. Biol. Cybern. 87, 301–314

- Berthoz, A. et al. (1982) Linear self-motion perception. In Tutorials on Motion Perception (Wertheim, A.H. et al., eds), pp. 157–199, Plenum Press