Recent developments in visuo-vestibular restitution of self-motion in driving simulation

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Abstract

Automotive research applications, from vehicle design to human factors, are of increasing importance in the domain of driving simulation nowadays. One of the reasons is the evolution of visual and kinesthetique rendering techniques and technologies, the other one is the industrial use of driving simulation as a cost effective design tool to be used in the vehicle development process. This latter has arrived to maturation as the rendering techniques allow today to carry out representative experimentations in the studied driving conditions but also because of the extreme strengthening of competition between car makers in cost effectiveness making more realistic the use of virtual prototypes. Virtual driver station design requires the use of head mounted display equipped driving simulators, virtual driving prototypes involve the use of large amplitude high fidelity motion platforms. For both of these systems perceptual and user assessment experimentations will be necessary to be carried out.

Résumé

Les applications automobiles, de la conception à l'étude des facteurs humains, deviennent de plus en plus importantes dans le domaine de la simulation de conduite. L'une des raisons se situe dans l'évolution rapide des techniques de restitution visuelle et kinésthésique, l'autre dans l'utilisation industrielle de la simulation de conduite comme outil de compétitivité dans le processus de développement de véhicule. Cette dernière est arrivée à maturation, grâce à la possibilité d'effectuer des expérimentations représentatives des conditions de conduite étudiées, mais également à cause du renforcement de la concurrence extrême dans la rentabilité des développements des véhicules qui rend l'exploitation des prototypes virtuels plus réaliste. La conception virtuelle des postes de conduite nécessite l'utilisation des simulateurs équipés de casque de visualisation, tandis que faire appel à des prototypes roulants virtuels suppose l'implémentation des plates-formes mobiles à haute performance et à grandes amplitudes. Pour l'emploi efficace de ces systèmes des expérimentations perceptuelles et des validations par utilisateur sont encore à mener.

Speed, distance and braking perception

The perception of speed by the driver in an automotive simulator was studied by several authors and was considered as under-estimated frequently [1], but studies carried out on large field of view recent simulators found opposite [2] or correct [3] estimation according to the level of fidelity of visual [4], kinesthetic, sound and traffic (Figure 1) cues restitutions and their proprioceptive integration.

Figure 1 – Perception of distance by the driver is critical in driving simulation

Nevertheless during car following tasks drivers were found to keep larger distances in a simulator than while driving real vehicles [3]. Restitution of braking in a driving simulator is still questionable on most dynamic driving simulators not equipped with large amplitude motion platforms even if driver's braking strategy seems more stable when driving dynamic than static simulators [5].

Visuo-vestibular integration: delays and gains

Although the influence of transport delays [6], [7] and temporal proprioceptive coordination on driving simulator fidelity is not sufficiently known yet, it would seem that its role is more important than that of the amplitudes of the produced sensorimotor cues. Psychophysical studies show that relatively great variations in perceived visual and vestibular acceleration values for the different degrees of freedom are well accepted by the human perception system [8]. Consequently some authors are suggesting that the use of scale factors of 0.2 and 0.6 in the restitution of vestibular cues are realistic [9], respectively for the translational and tilt-coordination channel.

Nevertheless a better knowledge of acceptable visual and kinesthetic gain values in relation of temporal proprioceptive coordination is necessary, according to the used (and very different) driving simulator configurations.

Virtual design tools and driving prototypes

The use of 3D interactive visualization tools for the interior and the exterior of a virtual vehicle is expanding. More and more car makers, automotive suppliers and road traffic rechearch instituts are using today corresponding technology in conjonction with stereoscopic screens, CAVES and head mounted displays. A position sensor detects the observer movements and allows to calculate and update in real time the image of the scene from the computed point of view. This is allowing both better depth perception (restitution of motion parallax when moving the head) and visuo-vestibular coordination, (ex.: VOR [10]), the latter allowing also to avoid sickness symptoms. Implementation of these technology is long awaited in the field of driving simulation and could enhance the quality of depth perception by the driver [3].
In the next future, 3D virtual vehicle visualisation techniques will probably be also used in driving simulation. The need of cost efficient tools in virtual vehicle design as well as vehicle testing, for vehicle system aid applications such as Adaptive Cruise Control, Stop and Go or Lane Keeping, crucial for traffic safety, will make necessary the use of representative high fidelity driving simulators along with comprehensive user assessment experimentations yet to be carried out.

References

[1] Snowden, R.J., Stimpson, N., Ruddle, R.A.(1998) Speed perception fogs up as visibility drops, Nature, 392(6675), p.450

[2] Jamson, A.H. (2000) Driving simulator validity: issues of field of view and resolution, Proceedings of the Driving Simulation Conference DSC2000, Paris, France, pp. 57-64

[3] 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, Proceedings of the Driving Simulation Conference DSC2000, Paris, France

[4] Joubert, T., Kelada, J.M., Kemeny, A. (1997) Display systems for truck training simulators, Proceedings of ITEC, Lausanne, pp.421-426

[5] Siegler, I., Reymond, G., Kemeny, A., Berthoz, A.(2001) Sensorimotor integration in a driving simulator: contributions of motion cueing in elementary tasks, Proceedings of the Driving Simulation Conference DSC2000, Paris, France

[6] Bloche, S., Kemeny, A., Reymond, G. (1997) Transport delay analysis in driving simulators with head mounted displays, Proceedings of the Driving Simulation Conference DSC'97, Paris, France, pp.85-98

[7] Kemeny, A.(2000) Simulation and perception of movement, Proceedings of the Driving Simulation Conference DSC2000, Paris, France, pp.15-22

[8] Van der Steen, F.A. (1998) An earth-stationnary perceived visual scene during roll and yaw motions in a flight simulator, Journal of Vestibular Research 8(6), pp.411-425

[9] Groen, E.L., Clari M.S.V.V., Hosman, R.J.A.W.(2000) Psychophysical thresholds associated with the simulation of linear accelaration, AIAA 2000 – 4294

[10] Kemeny, A.(1999) Simulation and perception, Proceedings of the Driving Simulation Conference DSC'99, Paris, France, pp.13-28