Virtual testing with driving simulators

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Abstract

Driving simulators have been used since more than 50 years for driver training and more than 20 years for human factor studies. Nevertheless, cost efficient industrial applications are recent and still limited to a small number of domains.

This seems about to change in the second half of this decade. After Renault in 2004 (Figure 1.), Peugeot (Chapron and Collinot, 2007) and Toyota (Toyota, 2007) have put into operation large amplitude X-Y motion based driving simulators with respectively 6m x 10m and 25m x 40m actuators. These simulators are also equipped with on-board cylindrical screen for high-end image quality display.

These technologies aim at high-level realism of rendering allowing the simulation of driver vehicle behaviour. Targeted applications are driver aid and active safety systems, such as ABS, Stop and Go ESP or X-by-Wire.

Résumé

Les simulateurs de conduite automobile sont utilisés depuis plus 50 ans pour la formation et depuis plus de 20 ans dans les études de facteurs humains. Cependant, les applications industrielles rentables sont encore peu nombreuses et limitées à peu de domaines d'utilisation.

Depuis la seconde partie de cette décennie cette situation semble évoluer avec l'arrivée après 2004 chez Renault (Figure 1.), chez Peugeot (Chapron and Collinot, 2007) et Toyota en 2007 (Toyota, 2007) avec la mise en place des simulateurs à plateformes mobiles disposant des actuateurs à large amplitude, respectivement 6m x 10m et 25m x 40m. Ces simulateurs disposent en outre des écrans cylindriques à large champs de vision.

Ces technologies visent un réalisme de restitution de haut niveau de qualité avec des applications de systèmes de sécurité active, telles ABS, Stop and Go ou encore X-by-wire.

Virtual testing

The use of driving simulators for this type of applications may target the early validation of system specifications thanks to the possibility of putting the driver in the loop for optimal driver comfort and vehicle behaviour but also for vehicle system design verification. This latter is unfortunately limited by the level of representativity of the used vehicle models. This is a serious limitation because of the limited knowledge of elasto-cynematics characteristics of a number of vehicle organs but also due to the lack of proprietary information from Automotive Suppliers.

Given these limitations, well tuned computational models allow to reduce the use of physical prototypes at different phases during the vehicle development cycle, especially when safe vehicle trials are impossible or limit the range of test situations.
This can be very useful at the very beginning of the vehicle project when production of the necessary number of advanced vehicle platforms would be too costly or even impossible when a entirely new forward or rear axle system are to be studied or on the contrary when only minor modifications are planned but vehicle comfort is to be tested.

Figure 1: Renault's high performance ULTIMATE simulator

Both active vehicle system specifications or final mmi validation are of primary interest, to be completed with other physical prototype testing for specific vehicle organs or necessary vehicle system testing when the complexity and tuning of the involved organs make this unavoidable.

Perceptual validity

Driving simulators provide most of the relevant visual cues present when driving in the real world. It has been found that a large horizontal field of view of 120° is needed (Jamson, 2000) for a correct speed perception. All of the above mentioned new driving simulators are equipped with a large field of view display systems. Nevertheless, motion parallax due to drivers head movements, and stereopsis are rarely found at present. This may explain bias in distance perception observed in driving simulator experiments (Panerai et al., 2001).

Figure 2. Traffic scene with informal driving rules

Several previous studies have provided evidence about the importance of satisfactory vestibular cueing (Reymond, 2002; Wierwille, 1983). It has nevertheless been shown that human accept a great deal of variation in perceived vestibular linear and rotational acceleration amplitudes (Van der Steen, 1998). Consequently some authors propose to use scale factors in rendering accelerations (Groen, 2000). A study on Renault's Ultimate simulator has identified various scale factors as prefered by professional trial drivers during lane changes: 0.15 to 0.6 (Dagdelen, 2006). Ongoing experiments are studying the role of jerk in acceleration perception (Haycock and Grant, 2007). Other factors may include cognitive factors, such as driving strategies, driver expectations or visual perception of the surrounding environment including vehicle traffic (Lacroix et al., 2007).

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