Application of driving simulation to road safety

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Abstract

This special issue reports on papers with driving simulation applications presented at the 2007 International Conference on Road Safety and Simulation held in Rome. Road safety depends on the roadway environment, vehicles and drivers and papers in this issue touch on each of these areas. The use of simulation to study these issues is becoming more and more popular and the cost effectiveness for developing simulation facilities and implementing simulation studies is improving dramatically with advances in computer technology and software.

Keywords – Driving simulation, driver behavior, road safety

1. Introduction

This is the fourth special issue devoted to driving simulation research and application concerning driver behavior and transportation system safety. The previous special issues have covered the themes "New Directions in Driving Simulation Research." [1], "Multidisciplinary new approaches to old problems: an overview of driving simulation research" [2]; and "New approaches to simulation and the older operator" [3]. This fourth special issue contains simulation based papers presented at the First International Conference on Road Safety and Simulation (RSS 2007) held at the University of Rome, Tre and hosted by the Department of Civil Engineering. A wide variety of papers were presented on road safety, and the papers here present a sample of typical simulator applications. The wide breadth of simulator applications presented at RSS 2007 is indicative of the increasing use of simulation for assessing the roadway environment, vehicle design and driver behavior. As indicated in Figure 1 simulator technology has increased significantly over several decades, and current capabilities of even personal computer (PC) based systems allows for fairly sophisticated applications. The papers presented in this special issue cover a wide range of simulator applications dealing with traffic interactions, vehicle control design, simulator design and normal and impaired driver behavior One paper also describes a new approach for embedding virtual reality scenes into real vehicle hardware.

2. Contributions

"Study of passing gap acceptance behavior using a driving simulator"

Traffic interactions are a significant road safety issue. This first paper analyzes drivers' passing maneuvers on two-lane rural roads using data collected with an interactive driving simulator.

	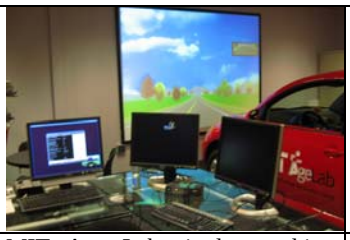	
Early calligraphic monitor display with subsidiary slide projected displays	MIT Age Lab single graphics channel projection with current PC graphics	Dutch truck driver training simulator with three channel blended projection and current PC graphics

Fig. 1 - Evolution of Driving Simulation Technology

The results indicate that the speed of the subject vehicle and its relation to the vehicle being passed are the most important factors affecting passing behavior. Results also show that drivers' socio-demographic characteristics and driving styles affect passing decisions.

"Visual inspections made by young and elderly drivers before lane changing"

Traffic interactions also include lane changing as considered in this second paper. Lane changing is a complex driving maneuver that could challenge elderly drivers. The aim of this study was to evaluate eye glances of young and elderly active drivers when performing lane change maneuvers. Visual scanning differences were found between the young and elderly driver groups. A better knowledge of the elderly drivers' behavior could be beneficial in identifying at-risk behaviors and to retrain older drivers to adopt safer behaviors.

"Locating in car controls: predicting the effects of varying design layout

Vehicle design can also impact road safety. This third paper addresses the location of controls within the vehicle. Two studies are described which aimed to understand the relative importance of different key design parameters on the location of in-car controls. Recommendations are given regarding the impact of alternative control design layouts on driver performance and ratings.

"Driving simulator sickness and validity: how important is it to use real car cabins?"

Simulator sickness is a common side effect in driving simulation studies and this effect may be influenced by the surround. This fourth paper describes a study focusing on whether or not to use a real car cabin. Results indicate that a real cabin set up is associated with a more conservative driving style. Drivers within a real car exhibited greater situational awareness than those in an "out-of-car" set up and the experience of simulator sickness may be moderated by enclosure within a real car cabin.

"Driver training using fused reality"

This fifth paper describes a novel virtual reality technique with head mounted displays. Head mounted displays with head orientation sensors allow a subject to view any part of the graphics data base by orienting their head in the desired direction. This technique, referred to as 'Fused Reality' allows an operator to view and interact with the physical environment in real-time while viewing the virtual environment through color-designated portals (i.e. painted surfaces such as window panels). This approach allows simulation to be embedded in real vehicles and provides an inexpensive way for including vehicle cabin hardware.

"Validation of speed perception and production in a single screen simulator"

Validation is a significant issue in gaining credibility for driving simulation applications. This sixth paper explores speed profiles of simulator versus real vehicle drivers on a 40 km desert route between two cities. The simulation driving scenario exactly replicated the real world road geometry while the sparse scenery was approximately reproduced. The results are consistent in showing that the simulator quite accurately reproduces speed sensations as a function of changes in the simulator speed.

"The relationship between chronic sleep deficits and distractions in young adult drivers"

Impaired drivers represent a significant road safety problem and fatigue and distractions factor significantly into this area. This seventh paper reports on a simulator study of the relationship between chronic sleep deficit and distractions on driving mistakes in university undergraduates. The results of this study indicate that young drivers with chronic sleep deficits are more likely to make driving errors when distracted.

"The impairing effects of alcohol intoxication and speeding on driving precision: analyses of additive and interactive effects"

Alcohol impaired driving is a significant problem in road safety. A simulator study is reported in this eighth paper that discusses whether a response conflict might also intensify the disruptive effects of alcohol on driving performance. Conflict under sober and alcohol impaired conditions was motivated by providing equal monetary incentives for careful simulator driving behavior (e.g., slow driving) and for quick, abrupt behavior (fast driving). Alcohol interacted with conflict to increase risky and impaired driving.

"A simulator for assessing older driver skills"

Driver behavior can deteriorate with aging which has been shown to be a growing road safety problem. This ninth paper presents data from a study designed to develop simulator assessment procedures for older drivers. The study compares the driving simulator performance of younger and older drivers. Driving scenarios were designed to minimize simulator sickness symptoms which appear to increase with age and be more severe in females. The simulator performance results show sensitivity to age, and do not appear to be affected by simulator sickness symptoms. The primary objective of this project was to develop a PC-based program in conjunction with a low-cost driving simulator that can be used for screening and potentially retraining the psychomotor, attentional, and cognitive skills of older drivers. Implications for road safety are discussed.

"Validity of driving simulator in assessing drivers with Parkinson's Disease"

Disease conditions can also affect road safety, and this tenth paper considers a simulator study of the clinical symptoms of Parkinson Disease (PD). In this study PD patients and normal drivers were assessed by a trained occupational therapist and driving instructor on open roads and in a driving simulator. The study concludes that PD drivers are significantly less competent drivers than the age matched control group and that simulator technology has the potential to be used in screening of unsafe PD drivers.

"Driving and activation of mental concepts"

Safe driving depends on how much the driver is able to create an internal representation of the relevant parts of the traffic environment. In this eleventh paper it is hypothesized that a series of mental concepts is successively activated during driving. Once a concept is activated, reactions to similar objects are facilitated (priming effect). The results of this simulator study show that subjects responded faster to emerging events if corresponding concepts were activated previously. Thus, mental activities during driving can be understood as a response to a sequence of activated concepts triggered by salient stimuli of the traffic scene.

3. Summary

The papers in this special issue on Road Safety and Simulation cover a range of topics associated with the roadway environment, vehicles and driver behavior. Simulation is proving to be a safe and efficient method for conducting research, assessment and training projects. Simulation is finding increasing application as the cost of hardware decreases and the capability of software increases. The application of simulation is also increasing with the proliferation of validation studies, e.g. [4], [5], [6]. These trends show every sign of continuing as the utility of simulator applications becomes more common knowledge.

References

1. Allen, R.W., Aponso, B.L. and Rosenthal, T.J. (2004). Special issue review of a symposium on driving simulation research and applications, *Advances in Transportation Studies*, 2004 Special Issue**,** 5-8.
2. Allen, R.W., Aponso, B., Rosenthal, T.J., "Multidisciplinary new approaches to old problems: an overview of driving simulation research," *Advances in Transportation Studies*, 2005 Special Issue, 5-8,
3. Allen, R.W., Reimer, B., "New approaches to simulation and the older operator," *Advances in Transportation Studies*, 2006 Special Issue, 9-20.
4. Mitchell, J.G.,. Schattler, K.L., Datta, T.K. (2005). Use of A Driving Simulator for the Evaluation of Safety Measures in Highway Work Zones, *Proc. TRB 84th Annual Meeting*, Washington, DC
5. Bella, F. (2005). Driving Simulator Validation for Work-Zone Design, *Proc. TRB 84th Annual Meeting*, Washington, DC