New approaches to simulation and the older operator

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Abstract

This special issue reports on papers presented at a symposium devoted to driving simulation research and applications concerning driver behavior and transportation system safety with emphasis on the older driver. This special issue is patterned after two previous special issues and reports on a third symposium held at the Massachusetts Institute of Technology AgeLab and United States Department of Transportation's New England University Transportation Center in Cambridge, Massachusetts.
The papers presented here range from typical highway, vehicle and traffic engineering, to the assessment of driver behavior and include considerations of roadway complexity, cognition and attention, training, fatigue, medical conditions and simulator side effects.

Keywords – driving simulation; driver behavior; older driver

1. Introduction

This is the third special issue devoted to driving simulation research and application concerning driver behavior and transportation system safety. The first special issue in 2004 resulted from papers given at a conference in San Diego, California, USA [1]. The theme of the first conference was "New Directions in Driving Simulation Research". A second symposium was held in Stuttgart, Germany, in September 2005 with the more general theme of "Driving Simulation Research and Applications" [2].

This third symposium "New Approaches to Simulation and the Older Operator" focuses on the behavior of older drivers as it relates to transportation safety.

The symposium's focus on older drivers and road safety is an appropriate and timely theme. 2006 is the year in which the first of the baby boomers, born between 1946 and 1964, turn 60. The "boomers" represent the first generation defined by the freedom and independence of the automobile [5].

The boomers are expected to live longer and to live differently than their parents. The disruptive demographics of this generation indicate that the number of miles driven and trips taken will exceed those of their parents [4]. The increase in time spent driving will demand enhancements in the vehicle and roadway.

Driver behavior and human factors are issues fundamental to roadway safety, and simulation has long been a means for safely and economically studying these issues. The collection of papers

in this special issue illustrates that driving simulation will be an important approach to redefining the vehicle and roadway to meet the needs of today's and tomorrows older driver.

Simulation can take on a variety of forms depending on the involvement of hardware as illustrated in Figure 1.

Depending on the face validity required for an application, the hardware can be configured to represent wide field of view visual displays with cabins or consoles, and some research can be carried out with simple desk top simulator configurations.

These configurations are represented in the research summarized in this issue. The hardware configuration of a simulation will be determined to a certain degree by the application. Professional driver training, such as for trucks and busses, requires a realistic configuration that represents the application. Research for applications involving typical non-professional drivers can be accomplished with much simpler configurations depending on the task that is being simulated. A common side effect of this research area is simulator sickness. Simulator sickness can be influenced by simulator configuration, task variables and participant demographics and these issues are addressed in several of the papers in this issue.

Fig. 1 - Examples of Simulator Configurations Used for Research and Training, from left to right:

the MIT AgeLab Driving simulator Miss Daisy;
a student completing training on a wide field of field of view desktop system;
the Arriva Bus Co. training simulator in the UK;
desktop units in a high school computer laboratory

2. Contributions

"The use of heart rate in a driving simulator as an indicator of age-related differences in driver workload"

The next generation of older adults is expected to drive more frequently than previous groups, and this study explores driver behaviour with cognitive performance tasks during simulated driving involving different levels of environmental complexity.

This paper discusses the degree to which driving complexity affects cognitive performance of older adults.

These results indicate that older adults appear to have more difficulty acclimatizing to the simulated driving environment. This paper confirms earlier findings suggesting that on easy cognitive tasks younger and older adults performed equally well; however, younger drivers performed significantly better on hard cognitive tasks.

"Aging yields a smaller number of fixations and a reduced gaze amplitude when driving in a simulator"

This study points out the importance of understanding if strategies for capturing visual information are affected by age and by the complexity of the driving contexts given the future trends in numbers of elderly drivers.

Numerous databases show that older drivers have proportionally more accidents when the driving context increases in difficulty, for example at intersections.

This research finds that older driver eye scanning behavior differs from younger drivers, which may reveal a "tunnel effect" (or perceptual narrowing) phenomenon when the driving context increases in complexity.

"Effect of old age on dual task performance during driving simulations of varying complexities"

This study examines the effects of road events and age on cognitive load in a simulated environment. Although older drivers demonstrate low absolute numbers of crashes, they have been reported to have relatively high crash rates and fatality rates when distance driven is considered. Accident analyses reveal difficulties for older drivers in complex driving situations. This increased risk could be partly caused by age-related declines in cognitive, perceptual, and physical abilities that are commonly associated with aging.

This study demonstrates the validity of the cognitive load approach for understanding older drivers' reaction to roadway events.

"Simulator performance differences between experienced and novice bus drivers"

The purpose of this study is to investigate whether there are significant differences between experienced and novice bus driver performance. The results showed that experienced drivers demonstrated greater caution but more confident behavioral strategies in some situations and in other circumstances drove slower and further away from the curb and used the brake significantly more often than novice bus drivers. These results are discussed with reference to the use of a driving simulator for novice bus driver training. Here we see the positive effects of age and experience.

"Early experience with HEADS: Hepatic Encephalopathy Assessment Driving Simulator"

Very little is known about the use of simulated driving to assess neurological impairment in the setting of liver disease. The specific aim this pilot study was to determine if driving simulation could identify individuals judged to be impaired by neuropsychological testing from a population of cirrhotic patients awaiting liver transplantation.

Driving performance of impaired cirrhotics differed significantly from a group of non-impaired plus healthy subjects. Several driving variables showed a strong correlation with impairment of at least one cognitive domain. A computer-simulated driving system such as HEADS may prove useful as a simple and practical means to assess cognitive impairment from liver disease. This study also reveals the road safety consequences of a disease condition associated with older drivers.

"The relationship between sleep patterns and the experience of simulator sickness and motion sickness"

Driving simulators are increasingly being used in training and research. Among the complications of driving simulator use is simulator sickness. This study focuses on individual differences in experience of simulator sickness. All participants drove a fixed-base driving simulator for about 20 minutes. The subjects exhibiting simulator sickness were older, reported a history of motion sickness, and also acknowledged sleep problems.

The results of this study highlight the need to include sleep patterns among the simulator sickness screening criteria.

"Simulator sickness amongst older drivers with and without dementia"

Simulators provide a safe, cost effective environment for mimicking driving tasks. Simulation can approximate real world driving, and is ideal for most types of driving research and evaluation but can induce the side effect of simulator sickness. The purpose of this study was to describe the prevalence of simulator sickness in older drivers, both healthy and cognitively impaired, that had been referred for driving evaluation. Results agree with past research showing females are more prone to simulator sickness. Results suggest that changes in how information is visually presented to drivers during simulation exposure may help reduce the incidence of symptoms which deserves further study.

"Simulator assessment of older driver proficiency"

Old drivers are at increased risk of being injured or killed in an automobile crash. Their fatality rate per miles driven is higher than that of any other age group except adolescents. This paper describes initial analyses of simulator performance data from a study designed to develop simulator assessment procedures for older drivers. The study compares the driving simulator performance of younger drivers (21-50) with older drivers (70-90). 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.

"Automated assessment and training of novice drivers"

Novice drivers pose elevated accident risks that are due to their lack of training and experience. This paper describes an experimental approach, including a driving simulation, which is designed to provide orientation, subject record keeping, training, performance measurement in a driving simulation and evaluation of driver behavior. Orientation and tutorial material were presented as part of the training regimen. Driving scenarios were designed to present cognitively complex situations involving hazardous, time critically scripted pedestrian, traffic and signal situations. The severity of the hazardous situations were designed to lead to driving errors for untrained drivers, but permit trained drivers to successfully accomplish them. Performance results illustrate the training value of learning from errors.

3. Summary

The papers in this Special Issue on driving simulation research and applications have covered several important areas: behaviour and performance effects of roadway complexity and driver cognitive load; the side effect of simulator sickness in this research area; medical issues in driving safety. Related topics were also covered in the 2004 and 2005 Special Issues. It is clear based on the material in these Special Issues that driving simulation plays an increasingly important and crucial role in research and assessment of older driver/vehicle/environment safety and system performance.

The availability of driving simulators at all levels of the research spectrum continues to expand with the availability of economical PC hardware and software. PC hardware will continue to advance in capability in the near future, and this should make driving simulators more appealing to greater numbers of practitioners in various fields.

The discussions among researchers during the symposium and papers presented in this special issue point to the importance of driving simulators as a human factors tool for emulating real world driving conditions in cases where on-road evaluations are cost prohibitive, there are excessive risks associated with the study, or where an increase in the consistency of experimental conditions is required.

The advent of modern computing technology and the availability of low cost driving simulators [3] highlight the growing importance of the topic of driving simulation research. It is critical that researchers using driving simulation continue to collaborate and discuss the unique nature of driving simulation as a human factors tool to ensure that "the behaviours observed in increasingly complex experimental simulations map onto drivers' behaviours in real-world driving experiences" [6].

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