Visual strategies using driving simulators in virtual and pre-recorded environments
Giannopulu, I; Bertin, R. J V; Espié, S.; Brémond, R.; Kapoula, Z.

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Road Safety and Simulation
Roadway design
Emerging technologies
Interdisciplinarity
Human factors

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A. Calvi, University Roma Tre, Italy
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<td>14:00-15:00</td>
<td>Registrations</td>
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<td>Welcome/Authorities</td>
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<td>16:00-16:30</td>
<td>Keynote Speaker</td>
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<td>16:30-17:00</td>
<td>Keynote Speaker</td>
<td>Driving simulation</td>
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<td>9:00-10:30</td>
<td>Plenary Session</td>
<td>Driving simulation: strategic tool for the safe road design</td>
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<td>Coffee</td>
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<td>11:00-13:30</td>
<td>Session A</td>
<td>Driving simulation: basic concepts</td>
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<td>Lunch</td>
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<td>12:00-12:45</td>
<td>Session B1</td>
<td>Driving simulation: drivers perspective</td>
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<td>Session B2</td>
<td>Driving simulation: drivers perspective</td>
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<td>Session C1</td>
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<tr>
<td>15:00-16:30</td>
<td>Session D</td>
<td>Driving simulation: evaluation of operating speeds</td>
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<td>17:00-18:00</td>
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Road Safety and Simulation

RSS 2007

International conference

Origins of authors and contributors
### Wednesday the 7th

**Aula Magna**

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<td>15:00-16:00</td>
<td>Welcome (authorities and hosting University)</td>
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**Chairsman**

Mr. Giovanni Da Rios

Full Professor of Roads and highways construction – Milan Polytechnic

16:00-16:30 | Keynote Speaker: Road Safety | Mr. Carlo Benedetto |
| 16:30-17:00| Keynote Speaker: Driving Simulation | Mr. Wade Allen |

17:00 | Opening Poster Session |

### Thursday the 8th

**Aula Magna**

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<td>9:00 – 10:30</td>
<td>Plenary Session: Driving simulation: strategic tool for the safe road design</td>
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**Chairsman**

Mr. Michael Manore

TRB – Chairman of TRB Committee on visualization in transportation

Considerations for Enabling Simulator Environments in Roadway Design

M.F. Trentacoste

Federal Highway Administration USA

Integrating actual road design into highway driving simulators for design, research, and consumer applications

T. Luke, N. Reed, A.M. Parkes

Transportation Research Lab. UK

Driving simulator study of a motorway car share lane: lessons for the design and implementation of novel schemes

L.T. Aarts, R.J. Davids

SIMOV The Netherlands

Behavioural effects of predictable rural road design: a driving simulator study

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<tr>
<td>11:00 – 13:30</td>
<td>Session A: Driving simulation: basic concepts</td>
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</table>

**Chairsman**

Mr. Stéphane Espié

Chairman – Mr. R. Wade Allen

Chairman – Mr. R. Wade Allen

Unité de Rech. Modélisation, Simulation et Simulateurs de conduite INRETS – MSIS

President and Executive Director Systems and Technologies STI

Interactive driving simulators: forewords

J. Wachtel

The Veridian Group, Inc. USA

Programs and practices to reduce simulator sickness: lessons learned from the field

N. Spannawasser, M. Stilke, R. Meisner

German Aerospaee Center (DLR) Germany

SimWorld – automatic generation of realistic landscape models for real time simulation environments – a remote sensing and GIS data based processing chain

K. Dahmen-Zimmer, M. Koszka, C. Gilb

Inst. Experimental Psych. University Regensburg Germany

Identifying proneness to simulator sickness in a fixed-based driving simulator

G.E. Burnett, A. Irune, A. Mowforth

Loughging University and VT, INRETS Sweden / France

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

J.J. Olstam, S. Espié

Loughging University and VT, INRETS Sweden / France

Combination of autonomous and controlled vehicles in driving simulator scenarios

D. Shinor, A. Ronen

Ben Gurion University of the Negev Israel

Validation of speed perception and production in STI – SIM single screen simulator

D.R. Tuppin, R.T. Wetsel, C.B. Price

Applied Simulation Technologies USA

Optimizing simulator performance specifications using driver performance measurements

I. Giaconalou, R.V. Berge, R. Bremond, Z. Kapoulia, S. Espié

INRETS-UMR, LOPC, INS - CNRS France

Visual strategies using driving simulators in virtual and pre-recorded environments

B. Weevers, M. Pankkonen, J. McAlulffe, M. Biedard

North. Ontario School of Med., Lakehead Univ. Canada

Validation of driving simulators: correlations between simulator-based and on-road driving evaluations, and their relationship to common tests of cognition

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Thursday the 8th
Session E
Aula B

11:00 – 12:30
Chairman – Mr. Jarkko Niittymäki
Chairman – Mr. Vincenzo Torrieri
Director Infrastructure East Ramboll Finland
Full Professor of Transportation University of Naples “Federico II”

Full presentation
A. García, L. Libreros, J. Contreras
Dept. Transport., Polytech. University of Valencia
Spain

A new microsimulator to evaluate road safety at skewed intersections

Full presentation
X. Wang, J.J. Lu
Dept. Civil & Envir. Engin. South Florida
USA

Simulation on terminal of exit ramp with freeway

Full presentation
A. Tagani
Swedish National Road and Transport Research Institute (VTI) and Linköping University
Sweden

Analysis of rumble strips and driver fatigue using traffic simulation

Full presentation
L. Domenichini, A. Giaccherini
University of Florence
Italy

Evaluation of the effects of traffic flow on road safety by means of numerical simulation tools

Short communication
J. Niittymäki, R. Nevala, K. Halme, S. Aitken
Ramboll Finland Ltd, Finn. Road Administration, Paramics-Online, Quadstone Group, South–Eastern Region
Finland

Simulation study of the main road network of southeastern Finland

Short communication
K. Koskinen, I. Kosonen, T. Luttinen, A. Schirocchi, J. Luoma
Helsinki University of Technology (TUT), Technical Research Centre of Finland (VTT)
Finland

Development of a nanoscopic traffic simulation tool

Short communication
B. Ciuffo, V. Punzo, V. Torrieri
University of Naples “Federico II”
Italy

Integrated environment of driving and traffic simulation

Thursday the 8th
Session F (IN ITALIAN)
Aula B

15:00 – 16:30
Chairman – Ms. M. Rosaria De Blasiis
Chairman – Mr. Francesco Bella
Full Professor of Integrated Road Design University Roma Tre
Associate Professor of Road and Infrastructures constructions University Roma Tre

17:00 – 18:00
Chairman – Mr. Carlo Benedetto
Full Professor of Road Infrastructures Theory University Roma Tre – CRISS Director

L’attività di ricerca del CRISS nel settore delle strade
Riflessioni sulle norme di progetto geometrico delle strade

Integrated environment of driving and traffic simulation
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<td>15:00 – 16:30</td>
<td>Chairman – Ms. Lisa Dorn</td>
<td>Director of Driving Research Group at the School of Engineering Cranfield University</td>
<td>Drivers oriented studies</td>
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<tr>
<td>Full presentation</td>
<td>M.T. Fillmore, E. Harrison</td>
<td>Dept. Psychology, University of Kentucky</td>
<td>The impairing effects of alcohol intoxication and speeding on driving precision: analyses of additive and interactive effects</td>
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<tr>
<td>Full presentation</td>
<td>J. F. Kremo, M. Baumann, D. Rösler</td>
<td>Chemnitz University of Technology, Germany</td>
<td>The concept of situation awareness and its application to driving</td>
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<td>Full presentation</td>
<td>N. Gothef, N. Abu-Alie, I. Anoch, M. El-M. Sul, A. Tah, N. Toledano, L. Lohia, A. Kasali, R. Kinyo</td>
<td>Occupational Therapy Dept., Harvard University, USA</td>
<td>The correlation between performance in driving simulator and visual attention and useful field of view, in different age groups</td>
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<tr>
<td>Full presentation</td>
<td>J. Bergeron, M.M. Eugène, E. Vallieres, M. Paquette, R. Villerand</td>
<td>Lab. de santé du conducteur, Université Montreál, Canada</td>
<td>Risky behaviours and driving performance of young male drivers in a simulator study of aggressive driving</td>
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<tr>
<td>Full presentation</td>
<td>F. Sagberg</td>
<td>Institute of Transport Economics, Norway</td>
<td>The sleepy driver</td>
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<th>Aula Magna</th>
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<td>17:00 – 18:00</td>
<td>Chairman – Mr. Fabio Ferlazzo</td>
<td>Associate professor of General Psychology, University of Rome “La Sapienza”</td>
<td>Drivers oriented studies</td>
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<tr>
<td>Short communication</td>
<td>C. Berthelon, I. Alline, C. Nachtergaele, C. Peirn</td>
<td>INRETS, France</td>
<td>Simulation of prototypical accidents scenarios for the study of novice drivers’ skills</td>
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<tr>
<td>Short communication</td>
<td>F. Lucidi, L. Maffia, C. Vellani</td>
<td>Dept. Psychology, University of Rome “La Sapienza”, Italy</td>
<td>Sleep related car crashes: risk perception and sleepiness at wheel coping strategy</td>
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<tr>
<td>Short communication</td>
<td>R. Hoening, J. Seilerstuecker</td>
<td>Inst. Erg. Indus., Psych., University of Luebeck, Germany</td>
<td>Driving and activation of mental concepts</td>
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<tr>
<td>Short communication</td>
<td>W. De Weerdt, H. Denis, A.E. Alkimarz</td>
<td>K.U.Leuven, Medical College of Georgia, Belgium</td>
<td>Effect of simulator training on driving after stroke</td>
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<tr>
<td>Short communication</td>
<td>M.C. Monnet, P. Van Elstande, T. Brenaz</td>
<td>INRETS, France</td>
<td>Driving situations expected by drivers in relation with their cognitive categories of urban streets</td>
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<tr>
<td>Short communication</td>
<td>R. Matos, M. Godinho</td>
<td>Human Movement Sciences, Tech. Univ. Lisbon, Portugal</td>
<td>Useful field of vision and peripheral reaction time in novice drivers – transfer to a real driving situation after a perceptual-motor training program</td>
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<tr>
<td>Short communication</td>
<td>H.C. Lee</td>
<td>School of Occupational Therapy, Australia</td>
<td>Validity of driving simulator in assessing ability of drivers with Parkinson Disease</td>
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<td>Short communication</td>
<td>M. Zajec, M. Jorsson</td>
<td>Dept. Computer, Oxford Brookes University, Dept. Com., Stanford Univ., Toyota Ltd., USA</td>
<td>Simulator based in car system evaluation with older adults</td>
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<td>Short communication</td>
<td>A. Sinley, T. Meahel, D. Donderi</td>
<td>Human Factors North Inc., Toronto, Canada</td>
<td>On-road and laboratory evaluation of bilingual variable message signs</td>
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<tr>
<td>Short communication</td>
<td>H. Nakayasu, Y. Seya, T. Miyoshi, T. Yagi</td>
<td>Dept. Info. &amp; Systems Eng., Kanagawa University, Information &amp; Manag., Toyohashi Sozo University, Japan</td>
<td>Visual perception and response behavior by driving simulator and eye tracking system</td>
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### Friday the 9th - Session C1 Driving simulation: road design

**Aula Magna**

**9:00 – 11:00**

Chairman – Mr. Maurizio Crispino

Full Professor of Roads and Highways Construction – Milan Polytechnic

- **Full presentation**
  - A. Kwasniak, A. P. Tarko, J. Ramos

  School of Civil Engineering, Purdue University

  USA

  Interactive driving simulators: simulation as design tool and validation

- **Full presentation**
  - B. Psarianos, N. Stamatis

  Nat. Univ. of Greece & University Pennsylvania

  Greece / USA

  RSIT - Knowledge-based support of high-crash site investigation

- **Full presentation**
  - M. Sarhan, Y. Hassan

  Dept. Civil & Envir. Eng., Carleton Univ.

  Canada

  Risk-Based Approach for Highway Geometric Design

- **Full presentation**
  - C. Benedetto, A. Calvi

  Dept. Sciences Civil Eng., University Rome Tre

  Italy

  Driver perceived discomfort and road safety

### Friday the 9th - Session C2 Driving simulation: road design

**Aula Magna**

**11:30 – 13:30**

Chairman – Mr. Yasser Hassan

Chairman – Mr. J.J. Lu

Associate Professor – Carleton University (Canada)

Professor, University of South Florida

- **Short communication**

  Univ. de Valenciennes et du Hainaut Cambrésis

  France

  Pre-crash investigation and interdisciplinary analysis using a dynamic driving simulator

- **Short communication**
  - Z. Hruby, P. Pokorny

  CEN, Research Transport Centre

  Czech Republic

  Implementation of road safety audit and inspection in the Czech Republic

- **Short communication**
  - J. Onorato-Beklevid, T. Hels

  Danish Transport Research Institute

  Denmark

  Road user’s socio-economic status and road safety in Denmark

- **Short communication**
  - F. D’Amico

  Dept. Sciences Civil Eng. Uni. Roma Tre

  Italy

  Impact of pavement damages on safety of roads

- **Short communication**
  - P.P. Jouwada, F. Gross

  Penn State University, VHB-BMI Associates

  USA

  Assessing the safety implications of differences in road geometry: application of case-control methods

- **Short communication**
  - F. Pan, J. Lu, Q. Xiang, G. Zhang

  Dept. Civil & Env. Eng. Univ. South Florida

  USA

  Signalized intersection level of service based on safety

- **Short communication**
  - N. van Nis, I. van Schagen

  TNO Institute for Road Safety Research

  The Netherlands

  Influence of credibility of speed limits and the use of an Intelligent Speed Assistant (ISA) on speeding behaviour

- **Short communication**
  - L. Sant’Andrea

  Dpt. Sciences Civil Eng. Uni. Roma Tre

  Italy

  A software for prediction of accident rate based on hazard analysis concept

- **Short communication**
  - O. De Mouzon, A. Garib, Y. Hassan

  Dept. Civil & Env. Eng., Carleton Univ., Roads Direct, Abu Dhabi Municip., Univ. Zagazig

  Canada / UAE / Egypt

  Safety evaluation algorithm for signalized intersections in Abu Dhabi (UAE) using artificial intelligence

- **Short communication**
  - Y. Papelis, G. Watson

  Prediction of vehicle loss of control during emergency manoeuvres

### Friday the 9th - Session G1 Infrastructure engineering, human behaviour and vehicle technology

**Aula B**

**9:00 – 11:00**

Chairman – Mr.

European Commission

Full presentation

- M. Winkelbauer

  Austrian Road Safety Board (KfV)

  Austria

  Best practices for road safety in Europe: a systematic approach

- M. Alonso, J. Plaza, H. Vega

  CIDAUT Foundation

  Spain

  Human factors in road infrastructure design: analysis of road layout influence in driver behaviour

- G. Ramos, J. M. Perandones

  CIDAUT Foundation

  Spain

  RANKERS, a road infrastructure safety effective enhancement

- F. Pan, J. Lu, Q. Xiang, G. Zhang

  Dept. Civil & Env. Eng. Univ. South Florida

  USA

  ESTIVING for Road Safety Research

  The Netherlands

  Safety evaluation algorithm for signalized intersections in Abu Dhabi (UAE) using artificial intelligence

- F. Pan, J. Lu, Q. Xiang, G. Zhang

  Dept. Civil & Env. Eng. Univ. South Florida

  USA

  Signalized intersection level of service based on safety

- N. van Nis, I. van Schagen

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  The Netherlands

  Influence of credibility of speed limits and the use of an Intelligent Speed Assistant (ISA) on speeding behaviour

- L. Sant’Andrea

  Dpt. Sciences Civil Eng. Uni. Roma Tre

  Italy

  A software for prediction of accident rate based on hazard analysis concept

- O. De Mouzon, A. Garib, Y. Hassan

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  Canada / UAE / Egypt

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  Penn State University, VHB-BMI Associates

  USA

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  Dept. Civil & Env. Eng. Univ. South Florida

  USA

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  Canada / UAE / Egypt

  Safety evaluation algorithm for signalized intersections in Abu Dhabi (UAE) using artificial intelligence

- Y. Papelis, G. Watson

  Prediction of vehicle loss of control during emergency manoeuvres
### Friday the 9th

#### Session G2

**Aula B**

**Infrastructure engineering, human behaviour and vehicle technology**

#### 11:30 – 13:30

- **Chairman – Mr. Andrew P. Tarlo**
- **Chairman – Mr. Jarkko Valtonen**

**Professor School of Civil Engineering, Purdue University**  
USA

**Helsinki University of Technology (TKK)**  
FINLAND

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<td>R. Thomson, S. Ottman, G. Lammer, K. Suolinen, J. Vaudor</td>
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<td>An analysis of driving performance evolution under high workload conditions</td>
<td>L. J. Zaloszewska, O. Carsten, H. Jamson</td>
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<td>Estimating road accidents of Turkey based on regression analysis and artificial neural network approach</td>
<td>A. P. Akgungor, E. Dogan</td>
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<td>Advanced visualization of road environments by means of programmable graphics hardware</td>
<td>F. Lankes, A. Husmann, M. Stammerer</td>
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- **Full presentation**

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#### Session D

**Aula Magna**

**Driving simulation: evaluation of operating speeds**

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#### 15:00 – 16:30

- **Chairman – Mr. Alfredo Garcia Garcia**
  
  **Professor Politecnico University of Valencia (Spain)**

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Thursday 8th November 2007
Time 9:00 am
Plenary Session
Driving simulation: strategic tool for the safe road design
Chairman – Mr. Michael Manore
Integrating actual road design into highway driving simulators for design, research, and consumer applications

M.F. Trentacoste

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Abstract
The ability to capture actual road conditions in an automated and cost-effective manner has increased significantly with advances in sensor technologies, computer storage and data processing capabilities, and analysis techniques. Likewise, the ability to utilize this information in a simulated road environment to (1) conduct research with human subjects regarding actual and proposed road designs, (2) enable practitioners to review and enhance road designs, and (3) assist with the visualization of innovative road designs to the general public, has become possible.

This paper presents the latest results of work at the Federal Highway Administration’s (FHWA’s) Turner Fairbank Highway Research Center in McLean, VA on creation and use of actual road simulations. First, the paper reports on the development of a vehicle and system, called the Digital Highway Measurement (DHM) System that utilizes multiple sensor technologies and computer analysis capabilities to collect raw data on highway geometry, road and roadside features and conditions, signage/markings, and pavement surface conditions. Data is then processes into readily useable electronic data files. The vehicle captures the data while operating at highway speeds and without special traffic control. [1] Previously, data collection of complete roadway geometry has been prohibitively expensive or highly inaccurate or inconsistent when produced from azimuth data collection by a vehicle traversing a roadway. [2] The level of data accuracy and repeatability on the DHM System is remarkable from a mobile platform. Post-processed road geometry information is imported into FHWA’s Highway Driving Simulator; roadside features are added to create a real-life simulation of the road.

The paper contains examples of road data captured for a two-lane rural road; use of the data to simulate the road with altered pavement markings; and then tests conducted in the simulator to determine effects on speeds and vehicle lane position from the pavement marking modifications. To validate the simulation results, a comparison was then made of the driving performance of subjects who drove the simulated road with another set of subjects who drove the actual road under the same range of pavement markings modifications. [3]

Finally, the paper presents another application of the FWHA Highway Driving Simulator to assist highway engineers in the design of an entirely new interchange design (diverging diamond) in the United States. This simulation was created using the computer aided design (CAD) files of the new interchange, as well as roadway and roadside features added to the simulation. [4]

Highway design engineers drove the simulation of the interchange to evaluate and modify their initial design. In addition, the video of the simulation was then made available to the State transportation department to use in its public hearing process to brief and convince private citizens of the value of the new design. Finally,
human subject tests were conducted on that road design in the simulator for both daytime and night time conditions. Results of these tests were used to recommend further modifications to the interchange to improve drivers’ understanding of the design. [5]

*Keywords – highway driving simulation, road data collection, road visualization*

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**References**


Driving simulator study of a motorway car share lane: lessons for the design and implementation of novel schemes

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Abstract

The UK faces growing congestion which already has a significant negative impact on the economy, the environment and quality of life. One of the Government’s strategies for tackling congestion is the effective management of existing road space [1]. In the last three years, the TRL driving simulator has been used to evaluate several different novel traffic management schemes designed for use on the UK motorway network. This includes: Active Traffic Management (ATM) and hard shoulder running [4], segregated motorway [3], and most recently, a car share or High Occupancy Vehicle (HOV) lane [2].

A Car Share lane is a lane of the road designated for vehicles with two or more occupants. They are a method of encouraging greener travel by giving priority to vehicles with multiple occupants. Car Share lanes are currently used in some urban locations in the UK. The TRL driving simulator was used to assess the design of a Car Share lane for use on the motorway. In particular, the project aimed to evaluate: the clarity of the signing and road markings; use and violations; impact on motorway exit behaviour and driver attitudes toward the scheme.

Forty-eight participants were recruited from a wide age and experience range to complete the simulator study. Participants were randomly assigned to one of two groups, in which participants drove either as a single occupancy vehicle or as a high occupancy vehicle. The virtual environment used was a realistic representation of the proposed M1 motorway Car Share lane scheme and numerous autonomous vehicles were inserted into the simulator scenario to present participants with different challenges to their driving behaviour.

Results of the study indicated a high degree of comprehension and compliance with the scheme. However, the rules of the scheme under emergency traffic management arrangements were less well understood. Together, the results of TRL trials on novel traffic schemes offer valuable insight into the best strategies for the design and implementation of novel schemes for UK motorways and trunk roads. Themes from each of the studies conducted in the last three years are drawn together to identify key lessons for best practice.

Examples include: the positive impact of informing drivers about the aims and rules of the scheme prior to use in terms of effective use and compliance and the need to avoid messages which conflict with the behaviour the scheme design intends to promote.

Keywords – novel traffic management, driver comprehension, driver compliance, design best practice
References


Behavioural effects of predictable rural road design: a driving simulator study

L.T. Aarts  R.J. Davidse

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Abstract

In the Netherlands, the Sustainable Safety vision [1; 2] is an important guide in improving road safety. In this vision, a central safety principle is ‘predictability’. This principle builds on the idea that the road layout should be recognizable and conform to the expectations of road users about the preferred driving behaviour of themselves and other road users, possible conflicts, and types of road users. Confirmation to these expectations would prevent errors that could lead to road crashes. One of the assumptions is that a road layout that is recognizable for road users, evokes more homogeneous, and thus more predictable driving behaviour. Recognizability of road layout increases when there is:

a) sufficient difference in road layout between road categories and
b) uniformity in road layout within road categories [see 3].

To study the effect of a recognizable and predictable road layout on driver behaviour, we examined speed and lateral position at rural roads that varied in recognizability in a driving simulator. Fourty-two participants drove three routes, each consisting of three different categories of rural roads (access roads, distributor roads, and regional through roads).

The routes only differed in the amount of recognizability:

Route 1 had random variations in road layout with no structural differences in layout between road categories;
Route 2 had differences in road layout between road categories but still with variation in layout within a road category
Route 3 had differences in road layout between categories and uniformity in layout within a road category.

Speed and lateral position were examined in light of

a) general safety effects [see 4] and
b) the more specific hypothesis that underlies the predictability principle: a recognizable road layout leads to more homogeneous road user behaviour [see 5] (and thus to more predictable and safer behaviour).

The results of this study showed that the more ‘recognizable’ road layout induced more homogeneous lateral positions between vehicles, whereas speed distribution remained unchanged. The more ‘recognizable’ roads also resulted in lower (and thus safer) mean speeds and lateral positions that were closer to the shoulder of the road. Because of the potential safety effects of road layout on behaviour, these effects should be taken into account before implementation of the design.

Keywords – road layout, sustainable safety, safety principles, predictability, driver behaviour
References


Thursday 8th November 2007
Time 11.00 am
Session A
Driving simulation: basic concepts

Chairman – Mr. Stéphane Espié
Chairman – Mr. R. Wade Allen
Programs and practices to reduce simulator sickness: lessons learned from the field

J. Wachtel
The Veridian Group, Inc. Berkeley, California, USA
e-mail: jerwachtel@aol.com

Abstract
Driving simulators continue to advance and prove more cost-effective. But while they facilitate ever more sophisticated research and find applications in certain military and industrial training programs, their use in those fields where they have the greatest potential societal benefit remains low. It is in the training and licensing of young, novice drivers, and in the retraining and retesting of older drivers who have lost their driving privileges due to medical or risk factors, where simulation has its greatest potential utility. But, with rare exception, this potential remains unfulfilled.

We believe that underutilization of simulation results from three principal factors:

a. lack of a reasonable criterion against which to measure simulator performance;
b. concern that simulators are too complex for use by non-specialists; and
c. unacceptably high simulator sickness rates, particularly among females and the elderly.

This paper touches on the first two factors, and emphasizes the third.

Nearly 15 years ago, human factors and simulation experts agreed that the inability to substantially reduce the incidence of simulator sickness was the single greatest factor limiting the contribution of simulation to the field of driver training and evaluation [1].

Unfortunately, this remains true today. And the costs of simulator sickness are more than monetary. Sickness causes participants to drop out of a research or training program; and for who stay despite experiencing discomfort, it adversely affects their performance and, in research, the validity of the results. Concern about sickness makes it more difficult to recruit participants for research or even to obtain approval to conduct the research at all.

Management decisions to reject simulation in organizational training programs have been made based solely on concerns about sickness. In short, concerns about simulator sickness, real and imagined, have the effect of reducing or eliminating the opportunities for certain population groups, especially the elderly, to benefit from the insights and guidance that simulation can provide about their ability to drive safely.

Although the physiological characteristics of simulator sickness are well understood [2], and although scales have been developed to predict and measure it [3], the minimization of simulator sickness remains a challenge. This may be because there are many subtle aspects of the simulation experience that contribute to this phenomenon, and because controlling it is as much art as it is science [4; 5].

One challenge to efforts to reduce simulator sickness is the great variety of hardware and software platforms, environmental settings, study designs, and participant populations in use. What works in one setting may have little benefit in another.
Because STISIM Drive is so widely used, its installed base offers the opportunity to compare practices employed by STISIM users that may shed light on the most effective measures to reduce the sickness problem.

The paper will report on a survey of STISIM users to learn about their simulator operations that might help explain why some experience high levels of sickness and others do not. The paper will present a compilation of practices that work, which can be put to immediate use by other users.

Keywords – simulation, simulator sickness, simulator adaptation syndrome, validity

References

SimWorld – automatic generation of realistic landscape models for real time simulation environments – a remote sensing and GIS-data based processing chain

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$^2$German Aerospace Center (DLR), Institute for Transportation Systems, Braunschweig, Germany
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Abstract

Real time simulation-environments are crucial for time and cost effective developments of new automotive technologies for replacing risky and extensive test setups. The quality of virtual models of vehicles, instruments and surrounding environment have significant impact on the range of applications where simulations can be successfully used. Due to an engineer-driven development of simulators, current vehicle-simulations provide well-elaborated, precise numerical models of crafts, sensors and assistance systems. On the other side the virtual representations of the environments used as backdrops are often very limited in their spatial extent and are lacking realism. This lack of realism limits the applicability of simulators and reduces especially the credibility of perceptually oriented test series. But even the generation of basic environment models requires -despite their low realism- a time-consuming, manual production process.

Therefore the interdisciplinary project “SimWorld” was initiated by the German Aerospace Center (DLR) to improve the generation process and the virtual depiction of the real world and – as a consequence – to provide easy access to realistic landscape models for numerous driving- and flight-simulators. Instead of the time-consuming manual production of more or less imaginary environmental models, SimWorld will provide realistic representations of the real world derived from air- and satellite-born remote sensing data. To achieve this, two DLR institutes have joined forces: the “Institute for Transportation Systems, Automotive” operates various car-, train- and traffic simulators and will cover the implementation and real-time display of the generated landscape models.

The “German Remote Sensing Data Center” specializes on analysis and visualization of geo-data and will provide an automatic processing chain to derive environmental models of the real world from remote sensing data. The major intention of this project is to improve the quality of the models available for simulation as well as the geographical extent of the models. With an automatic processing system in place, regions currently not available for simulators can be generated more time efficiently and with greater realism. Additionally a meta-data-base will be made available that allows for further simulation and testing of new technologies like e.g. radar-sensors, night vision systems or positioning systems such as GPS and Galileo.

The result of SimWorld – automatically generated realistic Landscape models- can not only be used for driving or flight simulators but is also suitable for applications like:
• train simulators
• advanced navigation and infotainment system
• 3D mapping for traffic management
• disaster management
• management of major events in sports, entertainment or politics

This paper describes the geo-data driven approach and discusses which data and street-related information can be gathered and extracted from air- and satellite-born imagery and GIS data (Geographical Information System) today and with regard to coming and future satellite missions. It will outline the concept for the automatization of the landscape modeling process, discuss the challenges and will give an outlook on already achieved and anticipated results of SimWorld.

**Keywords** – automatic landscape modelling, driving simulator, geo-data, real time simulation

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**References**

Identifying proneness to simulator sickness in a fixed-base driving simulator

K. Dahmen-Zimmer¹  M. Kostka¹  C. Gelau²

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Abstract
This study investigates which subjects are prone to simulator sickness and discusses the use of a questionnaire to identify persons who are likely to finish their participation in a simulator experiment due to simulator sickness.

Theory:
Simulator sickness should be carefully distinguished from motion sickness. In a fixed-base simulator the subject is not exposed to motion, but experiences a compelling sense of motion induced through exposure to changing visual imagery [1].

In contrast, motion sickness is evoked if persons are subjected to movements which have certain characteristics. Any sickness experienced in moving-base simulators may be true motion sickness, simulator sickness, or both. Symptoms of simulator sickness and motion sickness are similar: Nausea, drowsiness, dizziness, headache, occasionally even vomiting. Individuals differ in their proneness to simulator sickness, but so far tools to identify people, who are likely to quit an experiment early due to simulator sickness are lacking.

Method:
Our experiment was conducted in the fixed-base simulator of the University of Regensburg (Germany). Subjects were 65 experienced drivers (age range 30 - 80 years). Subjects were seated in a BMW limousine and drove using the steering wheel, gas pedal, and brake pedal. The driving scenery was presented on a 3x4 m screen.

Following the test drives in the simulator subjects were interviewed about their driving habits and strategies (for example avoidance of driving in the dark), bodily impairments (for example poor eyesight), and stress while driving.

Results:
Significantly more senior drivers than middle aged drivers and significantly more drivers with poor eyesight suffered severe symptoms of simulator sickness. Among the elderly drivers those subjects with a lower mileage per year were more prone to suffer from simulator sickness than subjects with higher traffic participation as car drivers. 90% of the subjects, who had to quit because of simulator sickness could be correctly identified by means of the questionnaire, and 70.5% of the subjects who did not suffer from any symptoms.
Discussion:
Our results provide evidence that there is a correlation between individual characteristics and the proneness to quit a simulator experiment early due to simulator sickness. This can be used as a starting point for the development of an instrument for the identification of subjects who can be expected to drop out from the sample due to simulator sickness.

However, more research is needed in order to cross-validate these results as well as to analyse the resulting from the selectivity of subject samples in driving simulator studies.

Keywords – simulator sickness, fixed-base simulator, senior drivers

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

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Abstract

With respect to the use of driving simulators as research and training tools, there are two key concerns. Firstly, it is well known that individuals can experience symptoms of sickness in driving simulators, manifested as feelings of nausea, dizziness and headaches [2].

Secondly, there are validity concerns, particularly behavioural validity, that is, the extent to which drivers behave in the simulator as they would in the real world [1; 3]. Both of these issues will be affected by many variables relating to the design of the simulator and the driving environment, as well as how the study itself is designed and conducted.

This paper describes a study focusing on one specific hardware variable, that is, whether or not to use a real car cabin. Decisions on this factor have considerable practical and resource implications for a research team. The study required 18 participants to drive on two separate occasions (each of approximately 20 minutes duration) within a fixed-base driving simulator. Participants were requested to follow a lead vehicle along a dual carriageway and at specific points to carry out secondary tasks. In a repeated measures design with counter-balanced order, participants conducted one drive in an “in-car” set up incorporating the body shell of a real car, and a second in an “out-of-car” set up incorporating only a car dashboard.

Measures were taken of primary driving and secondary task performance and perceived presence and sickness. At the end of the second drive, the lead vehicle slowed down suddenly. For this emergency braking event, measures were taken relating to brake reaction times and the extent to which participants were observed to show a physically noticeable reaction (e.g. by putting their hand/s over their face to protect themselves).

The study found several differences in driver behaviour across the two simulator configurations. When seated within a real car cabin versus the “out of car” set up, drivers:

- Slowed down more when carrying out the secondary tasks
- Followed the lead vehicle at a greater headway
- Responded more rapidly to the sudden braking of the car in front
- Showed greater physically noticeable reactions to the emergency braking situation
- Made more glances to the rear view mirror throughout the drive
- Made a larger number of short duration glances towards the in-vehicle display
- Gave higher ratings for presence, that is, the extent to which they believed they were really driving
- Gave lower ratings for simulator sickness (particularly related to oculomotor symptoms such as eyestrain, difficulty focusing, blurred vision, and headache)
Taken as a whole, these results demonstrate that the real car set up was associated with a more conservative driving style. This was particularly the case when drivers were performing secondary tasks concurrently with primary driving tasks.

Furthermore, there is evidence that drivers within a real car exhibited greater situational awareness than those in the “out of car” set up.

Finally, the research indicates that the experience of simulator sickness may be moderated to an extent by enclosure within a real car cabin.

Keywords – driving simulators, validity, simulator sickness

References

Combination of autonomous and controlled vehicles in driving simulator scenarios

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Abstract
Driving behavior experiments can either be conducted in the real traffic system, on a test track, or in a driving simulator. The real world is of course the most realistic environment, but it can be unpredictable regarding, for instance, weather-, road- and traffic conditions. The limited control possibilities often make it hard to design real world experiments with equivalent conditions for all subjects. Some experiments are also too dangerous or impossible to conduct due to ethical reasons. Test tracks offer a safer environment and the possibility of giving test drivers more equivalent conditions, but they have drawbacks regarding notably the variety and complexity of the driving context. Driving simulators on the other hand offer, indeed, a less realistic environment than the real world, but in which test conditions can be fully controlled and varied in a safe way.

A driving simulator is a tool which allows driving in a virtual environment. It is possible to reproduce driving situations from everyday life driving to specific situations, e.g. risky situations. As in actual situations, a main component of the driving context is the behavior of other road-users. The main reason for choosing driving simulators for conducting driving behavior experiments is often to get increased controllability and reproducibility. In order to ensure high reproducibility, the behavior of the surrounding road-users is often strictly controlled. This comes with the price of limitations in how complex situations that can be studied and limited realism regarding the surrounding vehicles’ behavior, due to complexity in programming. The complexity of programming can be decreased and realism increased by giving the surrounding road-users more autonomy. This leads to simulated situations closest to the real world, i.e. losing in reproducibility but gaining in realism. However, this environment is both safer and still more controllable than the real world.

Our hypothesis is that in some driving simulator experiments it is possible to gain in realism without losing too much in reproducibility by combining periods with fully autonomous simulated road-users with periods with only “enslaved” simulated road-users. The basic idea is to let the surrounding vehicles run in autonomous mode between the predetermined situations at which measurements are taken. When getting closer to the point in time or space where a situation or event is going to take place, the simulation of the surrounding vehicles should, in an unnoticeable way for the driver, turn from autonomous to controlled mode.
The aim of this paper is to discuss advantages, disadvantages, and difficulties with combining autonomous and “enslaved” simulated vehicles in driving simulator scenarios and to present means and methods for how the transition from autonomous to enslaved mode can be done. For illustrating this we will present and use a theater metaphor in which a scenario is broken down into three base elements, everyday life driving, play preparations, and plays. This concept is an extension of the theater metaphors presented in [1; 2; 3].

Keywords – driving simulators, scenarios, surrounding vehicles, traffic simulation, autonomous agents

References
Validation of speed perception and production in STI-SIM single screen simulator

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Abstract

Objective: validate the simulator for speed.

Method: A study was conducted in which 16 24-30 years old drivers drove on an actual 40 km desert route between two cities, and in a simulator in which the road geometry was replicated exactly and the sparse scenery was approximately reproduced. Actual speed ranged from 40 to 100 km/h. Half of the drivers drove in the simulator first, and half drove on the real road first. In each drive the drivers could not see the speedometer and had two tasks: speed production, in which they were told to achieve a predetermined speed, and speed estimation, in which they were told to accelerate or decelerate to a certain point, and then asked to estimate the speed.

Results: The comparisons between the real driving and the simulated driving yielded very high correlations. The correlation between real speed and produced speed on the road was nearly 1.0 (r=0.997), and in the simulator it was 0.86. The correlation between real speed and estimated speed on the road was also nearly 1.0 (r=0.997), and in the simulator it was almost the same (r=0.98). In both the simulator and the road, the estimated speed was slightly lower than the true speed, while the produced speed was slightly higher than the requested speed.

Conclusion: all the results were consistent in showing that the simulator quite accurately reproduces speed sensations as a function of changes in the simulator speed, and transfer functions to adjust simulator speed to reproduce speed sensations in actual driving are quite easy to achieve.
Optimizing simulator performance specifications using driver performance measurements

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Abstract
The use of driving simulators for training and research has increased dramatically on a world-wide basis. Most of these applications may be classified in one of four categories as follows:

• Study of driver health and human behaviors [1],
• Study of driver interactions with in-vehicle devices [2],
• Study of driver interactions with the roadway environment [3], and
• Measurement or modification of driver behavior in training [4].

Clearly, most of these applications use simulators to study drivers, but few of them analyze the simulators, or the effects that the simulators have on the drivers' behaviors. This issue becomes significant when one simulator cannot be used to replicate or to validate the findings developed using another simulator.

Differences in simulators are to be expected. They reflect unique approaches to simulation and integration implemented by various simulator manufacturers. Often, a manufacturer will define the performance specifications for a simulator before users define the scope of applications for that simulator. This leaves many simulator users with the challenge of matching the different simulators' performance specifications to the functional requirements of their applications. That task can be arduous! [5] Those who use simulators to train drivers are likely to ask for technical assistance in order to write procurement specifications for simulators that will be effective in their training.

This paper documents an iterative process that correlates simulator performance specifications to driver training requirements through repetitive steps including:

• Driver task analysis;
• Performance measurement;
• Data collection; and
• Data analysis.

The study chronicles the use of driving simulators over a two-year period while training law enforcement drivers in emergency vehicle operations (EVO). Because the data is application-specific, it can identify critical specifications for the driving simulator’s performance based on:
• Clearly defined driver skills and tasks to be learned;
• Objective measurement of trainee performance in the simulator;
• Correlation of simulator vehicle performance to trainee performance in actual vehicles;
• Analysis of technologies necessary to provide the required simulator performance.

The performance specifications for many existing driving simulators have relied upon models of projected human behaviors. [5] In contrast, this study uses objective measurements of actual driver performance collected during real training of more than 900 drivers. Statistical analysis of this data provides the foundation for both essential and optimal performance specifications for simulators used in EVO driver training.

This paper illustrates a 3 phase process that may be used to validate and refine simulator specifications for a variety of simulator applications, provided that the application collects objective driver performance measurements. Ironically, the measurement data needed to define simulator procurement specifications is only produced by the application itself! This analysis takes a step toward resolving that challenge.

The data summarized in this analysis suggests that this training application has been extremely effective. The simulator and training technologies have made a significant impact on the development of the drivers. Based on this analysis, the drivers may have significant impact on the evolution of simulator technologies.

Keywords – simulation, specifications, training, performance, measurement

References
Visual strategies using driving simulators in virtual and pre-recorded environments

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Abstract

Is simulator sickness due to the conflict between visual and vestibular information?

Recent data and especially those of our laboratory [1] mentioned that patients with vestibular loss exhibit similar symptoms of simulator sickness as healthy subjects. These observations suggest that simulator sickness could be dependent on visual information and provide rational for testing various visual environments.

The aim of this study is to compare subjects’ visual strategies on similar video-projected environments in a fixed-base driving simulator. Experienced car drivers aged 25-35 years are examined. None of the subjects have more than 10 hours of driving experience on a simulator. The subjects have normal or corrected-to-normal vision. They didn’t present cortical or sub-cortical disease (head injury or CVD).

All subjects are exposed to two visual environments: the first one is a real traffic urban scenario pre-recorded on video; the second is the 3D simulation of the same scene. The pre-recorded visual environment is a district of the center of Paris, between the Louvre and the Opera. Three cameras fixed on the roof of a vehicle are used for the recording. The position of the cameras is calculated from driver’s viewpoint. The virtual environment represented the scene above described on 3D images. These images are created by “Realax” software. For the comparison, the same architecture of buildings, textures and size of objects are used. The two scenes have the same physical and angular velocity. Prior to the video-projection, each subject is submitted to an optometric examination. This examination is composed of visual acuity, heterophoria and vergence movement measures.

In addition, the neuropsychological test “VOSP” is administered to all subjects. Once installed on the simulator, in both environment conditions the subjects are asked to use the steering wheel of the simulator as they would do in real life. Their visual strategies are recorded using a binocular eye tracking system (Eyielenk II).

In both environments, each subject performs eight trials. The order of the trials is randomly assigned to each subject. Each trial lasts around 2 minutes; the inter-trial interval is around 20 seconds. The whole experiment
takes 40 minutes. It is supposed that visual strategies depend on the degree of similarity between both environments.

Keywords – driving simulator, visual environment, binocular eye tracking system, visual strategy

References

Validation of driving simulators: correlations between simulator-based and on-road driving evaluations, and their relationship to common tests of cognition

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Abstract

Driving simulators are becoming increasingly common in both research and clinical settings. Therefore, it is important to determine how valid measures of simulated driving are as proxies for real driving. To that end, we present correlations between:

1) mistakes recorded by the simulator and driving evaluation scores for the simulated drive, and
2) scores from an on-road assessment and a simulation of the same route. (The route was similar to that used for G2 licence examinations in the Province of Ontario)

We also report associations between some common cognitive tests and driving evaluation scores.

We used the Manitoba Road Test to assess both on-road and simulated driving. It is a demerit-based test that assesses the following aspects of driving: starting, stopping, signal violations, moving on the roadway, passing (or overtaking), uncontrolled intersections/railway crossings/yield signs/pedestrian corridors or crosswalks, speed, turning, inattention. Within each of those areas, a number of problem behaviours is listed. Some problems are worth 5 demerits (e.g., following too closely), and some are worth 10 demerit points (e.g., cutting off another vehicle). A score of 50 demerit points or lower is considered a pass.

Mistakes recorded by the driving simulator (a STISIM 400) include the total number of occurrences of each of the following: centerline crossings, road edge excursions, speed exceedances, speeding tickets, stop sign or traffic light tickets, illegal turns, collisions, off road accidents, and pedestrians hit. The cognitive tests we used were versions A and B of the trail making test, and UFOV©.

Preliminary results show correlations between total number of simulator-recorded mistakes and driving scores ranging from .58 to .83.
The correlation between scores for simulated and real driving of the same route was .89. Trails A was a much better predictor of the driving evaluation score than Trails B ($R^2$ for A = .82, $R^2$ for B = .19, quadratic fits).

The correlation between UFOV-2 (divided attention) and the driving evaluation score was .59 for younger drivers and .68 for older drivers.

*Keywords – simulated driving, on-road driving tests, cognitive tests, validity*
Thursday 8th November 2007
Time 11:00 pm
Session E
Numerical simulation

Chairman – Mr. Jarkko Niittymäki
Chairman – Mr. Vincenzo Torrieri
A new microsimulator to evaluate road safety at skewed intersections

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Abstract
The microscopic traffic simulation models or traffic microsimulators are currently one of the most advanced tools for traffic study. These allow us to reproduce in detail the individual drivers' behavior and the vehicles' evolution, and to model them during long periods, taking advantage of the computers' capacities.

Nowadays, traffic microsimulators are mainly used for traffic planning, and for capacity studies of highway facilities, as well as, for evaluating intelligent transport systems (ITS). Nevertheless, with small improvements, these microsimulators can be used for studying other aspects, as, visibility problems at intersections or merging.

A new microsimulator was developed, called ValSim, which allows us to relate the skewed angle at intersections (merging or crossing) to the driver's angle of visibility for both direct vision and rear-view mirrors. It is possible to evaluate the road safety of a layout with a proposed horizontal geometry, using CAD format. To define the layout geometry ValSim uses polygonal data, specially for: road edges; road axis; stop line or yield line. The visual obstacle position is also defined by polygonal, for example for buildings and vegetation. It is also possible to define the speed limit sign position; and some other information such as an obstacle on the road. The use of polygonal data allows us to simulate any geometry. Polygonal data can easily be imported from or exported to CAD programs.

ValSim aims to allow designers to evaluate, by dynamical analysis in the geometric design process, the configuration of an intersection, and to verify possible conflicts at merging as well as at skewed crossings due to the lack of visibility.

The software simulates the driver's behavior while carrying out the incorporation or crossing maneuver. For each moment, it calculates the blind spot zones. If this blind area covers the opposite vehicle during a specified period, there could be a visibility conflict, which is highlighted.

ValSim's utilization allowed us to determine some recommendations for the geometric design of intersections, specifically, the skewed angle limits that provide an acceptable and safety design. On the other hand, it also allows us to compare different design alternatives in order to select the best. For example, it could be used for determining the best position of a stop line, the optimum radius on a merging lane, the appropriate speed limit, the adequate position of landscape gardening, the best taper length, etc. Besides,
ValSim not only distinguishes several types of vehicles in order to adapt designs for passengers cars, but also for trucks, buses and motorcycles. Some new criteria have been deduced with this new tool.

**Keywords** – microsimulator, visibility, skewed intersection, geometric design, safety
Simulation on terminal of exit ramp with freeway

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Abstract
Interstate highways are one of the most important components of the transportation infrastructure in America. Freeway ramps play an important role in the whole interstate transportation system. The rapid growth of traffic in America has caused queues on urban freeway off-ramps to spill back onto the freeway mainline.

This problem is present, with varying degrees of severity, at different locations throughout the United States of America. Spillback creates a potentially hazardous condition where high-speed traffic on the freeway suddenly comes upon traffic stopped and queued from the off-ramp.

Freeway exit ramp congestion may be attributed to three aspects: the increasing traffic demand; the improper traffic management & control as well as the design deficiency. According to AASHTO (American Association of State Highway and Transportation Officials) Green Book (a Policy on Geometric Design of Highways and Streets), the exit ramp includes three parts: the terminal of ramp with freeway, the ramp roadway itself and the terminal of ramp with arterial road (sometimes another freeway).

There are four types of terminal of ramp with freeway: one-lane tapered; one-lane parallel; two-lane tapered and two-lane parallel (Sometimes they are known as one-lane exit with optional lane, one-lane exit without optional lane, two-lane exit with optional lane, two-lane exit without optional lane). But, the AASHTO Green Book did not address clearly under what situation the different types of exit ramp should be chosen.

The choice of tapered exit ramp or parallel exit ramp in U.S are mainly the result of designer’s favorite, adviser’s related experience and local consultant office’s habit. In order to address the design issues on freeway exit ramp, this paper using simulation software CORSIM to compare the operational difference on these four exit ramp types based on case study in Florida. It tries to give a general guidance on how to choose different exit ramp type.

Some important parameters, such as traffic volume, operational speed, lane distribution, time headway, length of added lane (auxiliary lane), maneuver time, the percentage of heavy vehicle and the percentage of weaving, etc, are tested for sensitivity analysis by VB (Visual Basic) program.

Capacity and the average running speed are the main MOEs (Measure of Effectiveness) used in this paper. The finding of this paper may be applied for three purposes: Technical support for design; Reconstruction of an exit ramp and evaluation of a target exit ramp.

Keywords – freeway exit ramp, simulation, design
References

1. AASHTO Green Book
4. Statistical Models of Accidents on Interchange Ramps and Speed-Change Lane. By K.M. Bauer and D.W. Harwood
5. Advanced CORSIM Training Manual. Minnesota dept of transportation
Analysis of rumble strips and driver fatigue using traffic simulation

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Abstract

Vehicle-based active safety systems are currently being developed at an increasing rate. Systems such as adaptive cruise controls, collision avoidance systems and lane-keeping assistants all have a potential to improve the safety of the road traffic system. There is also a possibility to substitute or complement infrastructure-based safety improving countermeasures by more cost-effective vehicle-based alternatives. Physical milled rumble-strips can for example be substituted by “virtual” rumble strips presented to the driver as an in-vehicle driver assistance system.

Individual driver behaviour is naturally crucial for the functioning of vehicle-based systems. Driving simulators and instrumented vehicles are consequently important tools to study the potential impact of the systems. These tools allow studies of the systems’ impact on individual drivers and vehicles. However, to assure that the developed systems provide real benefits, it is necessary to estimate the impact on the overall traffic system. Traffic micro-simulation models that consider individual vehicles in the traffic stream will be useful for such evaluations. These models allow system functionalities and induced driver behaviour to be included in the driver/vehicle models of the simulation. This makes it possible to study the impact on the overall traffic system by means of traffic simulation.

This paper presents a traffic simulation framework for analysing the aggregation of individual driver/vehicle effects of in-vehicle systems to the traffic system level. Application of the simulation framework is exemplified by a study of centre line rumble strips on rural roads. The effects of physical milled rumble strips are compared to the effects of “virtual” in-vehicle rumble strips. Individual driver data from a driving simulator study are used for the traffic simulation.

The contribution of this paper is twofold. First, the paper illustrates the use of traffic simulation to aggregate observed individual driver/vehicle behaviour due to safety systems to effects on the overall traffic system. Secondly, the results of the simulation study presented in the paper indicate the effects of “virtual” rumble strips compared to the effects physical milled rumble strips. Differences in behaviour and response to rumble strips of alert and fatigue drivers are also considered. Numerical results will follow in the final paper.

Keywords – traffic simulation, driver assistance systems, system effects, rumble strips
Evaluation of the effects of traffic flow on road safety by means of numerical simulation tools

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Abstract
The scope of the work is to identify a valid parameter able to characterizing the effects of vehicle interaction in the traffic flow on road safety.

Many data shows the influence of traffic parameters on accident rates and considerable research has been conducted in recent years into establishing relationships between crashes and various traffic flow characteristics for road segments.

Most of the researches have focused on determining the relationship between accidents and highway traffic volumes, either at the aggregated level (e.g., Annual Average Daily Traffic) or disaggregated level (e.g., hourly volumes) levels [2]. Other work has also examined the safety of freeway segments as a function of other traffic flow characteristics, such as V/C ratios and level of service (LOS).

All countries around the world have standard guidelines to design geometrical characteristics of new or existing roads to be safe with reference to the condition of isolated vehicles. This approach doesn’t allows to account for the influence of traffic mix (in terms of flow, speed and other traffic parameters) on safety levels. To analyse the latter aspect detailed analysis efforts are necessary to understand how changes in the vehicle interdistances, speed differentials, acceleration or deceleration variability, gaps accepted for lane changes etc influence accident rates and safety. A powerful tool to study such relationships are microsimulation techniques, able to represent the vehicle’s cinematic parameters (position, speed, acceleration) of each single vehicle in the traffic stream.

Most of the currently existing microscopic traffic simulators are based on the family of car following, lane changing and gap acceptance models to model the vehicle’s behaviour. Microscopic traffic simulation is also a “perfect world”: no incidents can occur as far as the basic modelling hypothesis in the underlying car-following models is that vehicles should keep a “safety to stop distance”. Therefore, safety indicators based on vehicle behaviour able to represent risk potentials must be identified. Several safety indicators are present in literature, more or less compatible with the microsimulation capabilities (deceleration to safety time (DTS), Headway distribution], Time exposed time to collision (TIT), Time to accident (TTA) and Time to collision (TTC).

This paper explains the development of a new safety indicator, which takes into account some flow parameters able to represent the interaction between the vehicles and demonstrates how it can related to safety.
To reach this objective, many simulation experiments have been performed during which vehicle’s location, speed and accelerations have been gathered at every simulation step: for each specific traffic flow value, the proposed safety indicator and other indicators found in the literature were evaluated, constructing the time headway, speed and acceleration profiles for wide samples of vehicles. The most significant safety indicator has been chosen afterwards by means of a validation process based on the analysis of real accidents occurred on an Italian motorway during the period 1991-2001.

This innovative approach is becoming a powerful tool in the field of ITS applications assessment: some experiences show that microscopic traffic simulation are able to improve the knowledge of the risk levels within a traffic flow and can then contribute to a better road safety.

**Keywords** – road safety, microsimulation techniques, vehicle interaction, safety indicators, ITS

**References**

Simulation study of the main road network of South-Eastern Finland

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Abstract
The increasing number of heavy vehicles has caused traffic problems at the road network and border stations in south-eastern Finland.

In this study, a simulation model of the main roads of south-eastern Finland was developed to study the effects of an increasing number of heavy vehicles and traffic volumes. In addition, the feasibility of microsimulation as a studying method of larger road network was evaluated: modeled road network was more than 100 x 40 kilometers wide.

The simulation model was used to study the traffic performance with current traffic volumes and in two future scenarios: slow and fast growth of heavy traffic.

With current traffic volumes, the average speed is decreased especially at road sections around the major cities, at highway 15, and at the eastern parts of highway 7. In addition, the vertical geometry slows down heavy vehicles at highway 26. The majority of delays of the cross border traffic are caused by the queues at border stations. The longest vehicle queues are formed at highway 6 around cities, and at highway 7 when approaching the Russian border. In the grade-separated intersections of two lane roads the main problem is merging the queued main traffic flow from the merging ramps.

In the scenarios, the traffic conditions weaken most around cities and at highway 7 close to the Russian border. The border queues lengthen due to the lack of check point capacity, and risk of border queues blocking the intersections near to the Vaalimaa border station increases. The travel times through the study area to the border stations increase 4 to 6 minutes (3 to 4 percent), not including the increased waiting time at the border. The effects of slow and fast growth scenarios of heavy traffic only vary slightly. This is due to the small difference in total traffic volumes between scenarios, and considerably high number of heavy vehicles in both scenarios and in the current traffic situation.

According to simulation, more capacity is needed primarily at highway 6 around Kouvola city. Also the vehicle overtaking possibilities of two lane highways 6 and 15, the eastern parts of highway 7 and the uphill sections of highway 26 need to be improved. The main intersections around largest cities will also need more
capacity. The efficiency of border control has to be improved or larger parking areas built for queuing trucks, in order to avoid border queues from blocking the road network.

In general, the simulation model of the south-eastern main road network is able to express the traffic conditions fairly realistically, and the modeling results can be used as rough estimates of the traffic performance in the network.

However, there are some considerable lacks in the modeling. The estimated traffic volumes and distributions around cities are not accurate enough for microsimulation use, and the lack of a validated overtaking model on two lane roads decreases the reliability of the simulation. Regardless, the network model built in this project can be utilized in future projects with minor changes, when more accurate traffic studies of the network, or parts of it, are needed.

Keywords – main road network, microsimulation, heavy vehicles, traffic performance
Development of a nanoscopic traffic simulation tool

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Abstract
Microscopic simulation models have been successfully used in several fields of traffic engineering including capacity evaluations and optimization of traffic control timings. However, the safety evaluation has been out of reach of these tools so far, mainly because human behaviour has not been modelled sufficiently. Traffic behaviour constitutes a highly complex research subject. The occurrence of accidents is an even more complex phenomenon, frequently involving human errors, which are difficult to cover in a microscopic simulation model, and rarely even attempted.

The objective of the study is to develop a new simulation tool for nanoscopic modelling of traffic. By nanoscopic simulation we mean a method for modelling the behaviour of a driver or other road user based on theories and empirical data on human psychophysical properties and behaviour. Specifically, we aim to expand a current microscopic simulator platform, HUTSIM, into the field of nanoscopic simulation.

The modelling will focus on the interaction of driver and pedestrians as well as car-following situations in urban environment. The structure and operating principles of proposed model will be presented as well as methods for calibration and model validation with instrumented vehicle driven by test subjects in real traffic environment.

One key component of the proposed driver model is the modelling of secondary tasks performed by the driver.

This secondary task can be an explicit task, such as using a mobile phone, operating an in-vehicle navigation system or tuning a car radio. However, the secondary task is part of the driving process even when driving without using any additional devices because the drivers always tend to perform additional cognitive tasks while driving (e.g. thinking of affairs not connected to driving task, looking at advertisements or talking to passengers). The proposed model will be applicable to safety simulation and especially modelling the effect of in-vehicle telematics on driver behaviour. In addition to this, it can be seen as an attempt to increase knowledge on driver behaviour in general.

Keywords – microscopic traffic simulation, driver modelling, traffic safety, in-vehicle telematics
References


Integrated environment of driving and traffic simulation

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Abstract

Major advantage of using a driving simulator is the chance of carrying on safe experiments, in a controlled environment, assuring equal driving conditions to all the test drivers. Nonetheless the reliability of results is seriously affected by the likelihood of the simulation environment. Behaviour of surrounding vehicles, generally referred as the traffic scenario, has been recognized as a key element in a realistic simulation.

A realistic traffic flow generally requires that:

(i) autonomous vehicles move around the interactive one in a realistic manner, i.e. showing realistic vehicles’ interaction dynamics;
(ii) vehicles move according to macroscopic behaviour of traffic streams, e.g. the higher the number of vehicles on the road, the lower the average speed of the traffic stream;
(iii) while moving on a network in a simulation, a driver should meet the “same” traffic he would find in the real network, i.e. the dynamic pattern of traffic flows on the simulated network should closely resemble the actual one.

In order to fulfil the first requirement accurate driver models are necessary [1; 2; 3; 4]. Then the second issue requires that the aggregate behaviour of a traffic stream, resulting from individual behaviours, was consistent with the macroscopic traffic flow dynamics [4]. This can be achieved, for example, by calibrating individual driver models using aggregated data, like the time series of speeds on detectors, rather than microscopic behavioural data [5]. Finally, the third point requires that the traffic simulation was extended to the whole network [3].

When the last task is accomplished by a macroscopic or a mesoscopic traffic flow model, effects of some ITS strategies on the network flow propagation cannot be properly accounted for. It is the case of the design evaluation of ADAS (Advanced Driver Assistance Systems) or IVIS (In-Vehicle Information System) technologies, that affect the individual behaviours and choices of drivers.

In the aim of providing the simulation environment with reliable and comprehensive traffic scenarios, the microscopic traffic simulation software AIMSUN NG has been integrated within the dynamic driving simulator available at the TEST Driving Simulation Laboratory. The software allows us to easily cope with complex traffic scenarios like the ones resulting from the implementation of ITS strategies, e.g. bus priority at intersections, traffic responsive control strategies, etc. Moreover, the available option of implementing whatever user-defined driver model within the simulation environment, turns out to be essential for emulating (and then evaluating) e.g. the effects of ADAS. Finally, according to the first results of the validation process, the integrated environment shows to be suitable for experimental driver behavioural
analyses (with the great advantage of being able to perform controlled experiments, without the need of complex data estimation procedure).

This paper therefore describes criteria, features and results of the traffic integration, as well as the validation process against real traffic microscopic data.

Keywords – driving simulation, traffic flow micro-simulation, validation

References

Thursday 8th November 2007
Time 3:00 pm
Session B1
Driving simulation: drivers perspective
Chairman – Ms. Lisa Dorn
The impairing effects of alcohol intoxication and speeding on driving precision: analyses of additive and interactive effects

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Abstract

Automobile crash reports have shown that up to 40% of fatal crashes in the United States involve alcohol and that younger drivers are over-represented among these alcohol-related crashes [1]. The impaired ability to drive under alcohol is usually attributed to the drug’s disruptive effects on motor coordination and the ability to sustain attention. However, there is also growing evidence that alcohol use among young drivers is associated specifically with risky driving behaviors, such as speeding, which likely contributes to the over-representation of these individuals in alcohol-related crash statistics.

The reason for the association between alcohol use and risky driving behavior is not clear, but it might involve the ability of alcohol to impair cognitive mechanisms that normally serve to inhibit or suppress inappropriate actions.

This paper reviews the results of recent laboratory studies that used cognitive control models to demonstrate how alcohol impairs the ability to inhibit pre-potent (i.e., instigated) responses resulting in the display of impulsive and under-controlled behavior [2]. The authors also describe how these impairing effects of alcohol can be intensified in conflict situations in which behaviors yield both rewards and punishments [3]. The authors explain how such alcohol-induced impairments of inhibitory mechanisms might actually exert considerable disruptive influence on higher-order, executive cognitive functions, such as those involved in driving. The evidence is then extended to the study of alcohol effects on simulated driving performance (STISIM Drive, Systems Technology, Inc., Hawthorne, CA).

These driving studies are based on the general working hypothesis that some impairments of driving performance could reflect direct alcohol-induced impairments of the ability to inhibit inappropriate responses, especially for aspects of driving performance impaired at low blood alcohol concentrations (i.e., below 0.08%) that are insufficient to disrupt motor coordination.

The authors present findings relating alcohol effects on aspects of driving performance to the impairing effect of the drug on drivers’ inhibitory control, and how such impairments can be exacerbated in conflict situations. The findings provide new insights into how alcohol might interact with personal and environmental factors that also impair driver performance and increase crash risk.

The results also highlight the importance of examining the joint influence of multiple factors as contributing to impaired driver performance and its negative impact on traffic safety.
Other factors such as impulsivity, conduct disorder, and disorders of attention might also be associated with the tendency to speed while intoxicated and should be investigated in future studies.

*Keywords – alcohol, inhibitory control, cognition, driving, impulsivity*

**Acknowledgment**

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**References**

The concept of situation awareness and its application to driving

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Abstract

Drivers have to correctly perceive and interpret the relevant objects and elements of the current traffic situation and they have to consider these elements in planning and controlling their behaviour. Such elements may be other traffic participants, the surface of the street, or traffic signs. A concept that aims at describing and integrating these different cognitive processes is situation awareness [1].

Endsley’s model [1] does not specify the mechanism of how the interaction among the different levels of situation awareness is accomplished. That is, how one achieves the comprehension of a situation from the perception of the elements of this situation, and how assumptions about their future behaviour are generated. In Baumann and Krems [2] we propose a model of how situation awareness is “constructed” while driving. Basically this model assumes that the comprehension of the meaning of perceived situation elements is achieved through comprehension processes that are similar to those involved in language comprehension, in particular in text understanding [3]. By these comprehension processes a mental representation of the current situation is constructed and constantly updated with new information. If in-car tasks performed while driving impose a significant load on visual attention and WM, then one can expect that the construction, maintenance, and updating of the situation model is impaired.

In several experiments we tested predictions about the effects of in-car tasks on situation awareness. To test these predictions an experimental paradigm was developed to measure the visual and cognitive demands of in-car tasks. This paradigm is based on the use of a secondary task that has to be performed concurrently with the in-car task to measure the visual and cognitive demands of this in-car task. The secondary task consists of a choice reaction task where the correct response to a presented stimulus depends on the current response context. This context changes frequently. Therefore, to respond correctly to a presented stimulus, one has to perceive the stimulus and also one has to remember the correct context. We argued that the pure detection rate in the secondary task depends mainly on the visual demand of the in-car task that is performed concurrently with the choice reaction task. The hit rate, that is the proportion of correct responses of all responses made, should be sensitive to the cognitive demand of the in-car task.

In the first experiment the visual and cognitive demands of three in-car tasks were evaluated with this procedure.

In the second experiment the effect of these tasks on drivers’ situation awareness was evaluated in a driving simulator study. In agreement with the model we found that those tasks that were evaluated as highly visually or cognitively demanding lead to more errors at the comprehension level of situation awareness.
When the drivers performed a speech interaction task their representation of the situation behind them was impaired. The cognitive demand associated with this task may have impaired the maintenance of the situation model in memory and lead to forgetting information.

**Keywords** – situation awareness, secondary task, distraction, visual demand, cognitive demand

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**References**

The correlation between performance in driving simulator and visual attention and useful field of view, in different age groups


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Abstract

Background:
Driving ability is considered to be one of the most important roles of a person in modern time, thus it is the focus in occupational therapy intervention and research. One of the main clinical and research objectives is to develop an evaluation process, which will best predict ability to drive. To date the assessment process is divided into two parts; the off road assessment (e.g. visual search tests) and the on road assessment. In recent years, driving simulators has been used to assess driving ability in an ecological valid context. They have been found to be effective as a screening tool and they enable evaluation and treatment in a safe environment [4; 5]. Due to the growing use of driving simulators in driving rehabilitation there is a need to investigate their psychometric properties [2; 3].

The purpose of this study was to examine the relationship between performance in a driving simulator and visual search and useful field of view as well as study the effect of age on the performance.

Methods:
Fifty three healthy adults participated in the study. They were divided into 2 age groups: younger (mean age 28.2 ± 8.0) and older (mean age 59.9 ± 6.6) adults. All the participants had a valid driving license and stable medical condition.

The tests used in this study were:
1. UFOV (Useful field of view) which assess is widely use for assessment of driving ability;
2. VISSTA (Visual Spatial Search Task), which assess visual-spatial search;
3. STISIM driving simulator module 100 that was developed by Systems Technology, Inc.; and
4. SFQ (Short Feedback Questionere) which assesses the subjective feeling of virtual presence.

Results:
The younger group completed the driving scenario significantly faster than the older group. Significant correlations were found between reaction time in the VISSTA and the time it took to complete the scenarios and between the three subtests of the UFOV and several parameters from the simulator: number of accidents, number of traffic violations and the time it took to complete the scenarios. Finally, no significant differences were found between the two groups in the sense of their virtual presence within the driving scenarios.
Conclusions:
The results of this study are comparable with findings reported in the literature about the tendency of older people to slow down while driving, in order to compensate for physiological changes such as decrease in reaction time. This further supports the validity of the driving simulator. Moreover the correlations with the visual search task and the UFOV support the concurrent validity of the driving simulator as an additional evaluation tool for assessing driving ability. Although the results of this study indicate to the potential of using driving simulator in rehabilitation we must be cautious in the interpretation due to the small sample size. We are currently in the process of analyzing data from a larger sample as well as performing a study with clinical population.

Keywords – driving simulator, validity, visual search, useful field of view

References
Risky behaviours and driving performance of young male drivers in a simulator study of aggressive driving

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Abstract

The presence of stress and aggressiveness in the traffic environment no longer needs to be demonstrated [1]. Aggressive driving is perceived by many road users as one of the most significant problems of modern day driving [2] and as a growing challenge to highway safety [3]. According to literature, young male drivers are especially concerned with aggressive and/or reckless behaviours on the road [4]. Indeed, risky driving is consistently associated with age, gender and driving exposure. Young drivers tend to engage in on-road risky behaviours and aggressive driving more than older drivers. Also, men are more reckless and hostile on the road [5].

The objective of the present study was to analyze relations between driving performance and expressions of anger, stress and risky behaviours in a driving simulator, in order to contribute to a better understanding of the interactions between the young male drivers’ personal characteristics and their behaviours on the road. Sixty young male drivers (18-25 years) participated in this study. After providing informed consent, participants completed a socio-demographic inventory and a number of questionnaires bearing on selected personality variables (affective attitudes, anxiety, narcissism), stress vulnerability and driving stress. Afterwards, all participants completed a standard driving simulation task consisting of a practice trial and an actual driving session recreating everyday on-road trivial conditions and major obstacles. This experimental session was held in the driving simulator of the Université de Montréal: it is a fixed-based simulator composed of an automobile, fully functional pedal and dashboard, and a large screen showing computerized highway images of urban streets projected by an RGB projector.

The data-processing programming comprised scenarios reproducing rather frequent situations on the road, likely to cause feelings of irritation and contrariety in most of the drivers. In addition, a time pressure was added; participants were told that they were driving to an important appointment and should try to arrive on time. The simulated environment was completely interactive and was reproducing real-time participants’ behaviours. Each participant’s driving session was audio and video recorded. After completing the task, participants completed behaviour and anger self-report scales.

The behaviours selected for observation were those that are commonly included in reckless behaviours or in ‘aggressive driving’ lists (e.g. high speed, honking, passing on the shoulders, verbal anger expressions, etc.). Moreover, in order to evaluate participants’ stress and aggressive manifestations, three judges independently...
coded the video and sound of the participants’ overall driving session. Examples of aggressive observed variables were the number of honks blown and their type (short or long), the number of aggressive commentaries and the number of hostile gestures toward other drivers.

The results indicate first a linear relation between the driving performance of the participants during the experimental session on the simulator and the data-processing programming of the scenarios. Secondly, an aggregate score of mean speed, maximum speed and number of collisions with other vehicles in the interactive simulated environment was computed as an indicator of reckless driving. In accordance with our hypotheses, the results show significant relations between risky driving during the experimental session in the simulator and real-life driving records. There are also significant relations between personality variables (anxiety, narcissism and stress vulnerability), driving performance (e.g. vehicle control response under time pressure) and aggressive manifestations.

Taken as a whole the present results confirm that aggressive driving behaviours increase with both the irritability of the situations and the driving stress vulnerability. The reckless driving indicator in driving simulation is significantly related to real-life driving criterions (accidents and traffic violations). It is also significantly related to self-reported frequency of on-road reckless driving.

So, driving simulators seem to be promising instruments for individual evaluation of on-road reckless driving, namely for the possibility to study driving behaviours in a controlled environment. Future studies are necessary to relate the reckless driving indicators in simulated environment with real aggressive driving behaviours on the road.

Keywords – aggressive driving, stress, driving simulator, young drivers, risky behaviours

References

The sleepy driver

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Abstract

Falling asleep while driving, or even driving while fatigued without actually falling asleep, are among the most frequent causes of road crashes. The recent decade has seen an increasing amount of research related to fatigued or sleepy driving.

The present paper is a review of research on the following issues regarding fatigued driving:

1. The nature and causes of driver fatigue,
2. The incidence of falling asleep while driving,
3. The share of accidents caused by fatigued drivers,
4. Circumstances under which drivers tend to fall asleep,
5. Drivers’ awareness of signs and symptoms of sleepiness,
6. Fatigue indicators and detection methods,
7. Drivers’ knowledge of fatigue-related risk,
8. Individual and organisational strategies for preventing and combating fatigued driving, and
9. Implications for road and vehicle-based countermeasures.

The review is based on recent work at the Institute of Transport Economics [1, 2, 3, 4, 5], as well as on other relevant studies.

Some of the findings from the mentioned studies are:

- About 10% of drivers report to have fallen asleep at least once during the last 12 months. Estimates from other studies vary, but tend to be in the same order of magnitude.
- About 8% of injury road crashes are caused by a driver being fatigued or falling asleep. Estimates from other studies vary, but tend to be in the same order of magnitude. The estimates also depend on the type of accident.
- Sleep-related crashes are, on average, more serious than crashes caused by other factors; this is due to the fact that sleep-related crashes often occur under conditions of relatively high speed (e.g., rural roads with little traffic).
- The most frequent sleep-related crash type is driving off the road.
- Young, inexperienced males are more likely than other driver groups to fall asleep while driving.
- About 40% of drivers who are involved in a fatigue-related crash, report some kind of sleep-problem.
- Most drivers are aware of fatigue symptoms before falling asleep at the wheel, but a few report having fallen asleep without noticing any early signs.
- Most drivers know that stopping to have a nap is the most efficient countermeasure when feeling sleepy during driving, but few drivers actually do this.
References


Thursday 8\textsuperscript{th} November 2007
Time 5:00 pm
Session B2
Driving simulation: drivers perspective

Chairman – Mr. Fabio Ferlazzo
Simulation of prototypical accidents scenarios for the study of novice drivers' skills

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Abstract
To improve the realism of the images and of the situations used in driving simulators, we selected scenarios which were prototypical situations of accident processes [1] and introduced them in such a device. The prototypical accident scenarios were implemented using objective data from in depth investigations of on the spot accidents which give a maximum of information about the characteristics (driver, vehicle and infrastructure) and the temporal description of the accident [2].

In order to test the capacities of these scenarios to produce behaviours similar to behaviour encountered in the real driving, we compare the skills of novice drivers to the skills of experienced drivers, known to have more efficient coordination and better performances [3; 4].

Participants were novice drivers with a very recent driving licence obtained through traditional driver education (N=12) or early driver education (N=7). Experienced drivers (N=11) had their driving licence for more than 3 years. Participants were seated in an interactive driving simulator and had to drive normally. Dependent variables were speed, response time (accelerator, brake), lateral position of the vehicle and inter-vehicular time.

Of course, insofar as the accident is of multifactorial origin, a small percentage of subjects actually collided. However, results concerning the drivers' behaviour as a function of experience were in relative agreement with the literature. Two scenarios out of five clearly reflected a driving experience effect; they simulated an unexpected event that could be assimilated with an emergency situation. We also found specific behaviour: experienced drivers more often tend to make avoidance manoeuvres, novice drivers with traditional driver education more often tend to collide. The lack of specific behaviour in the third group of drivers could be proof of safer behaviour.

Other scenarios must be tested and included in our driving simulator. They could be used to improve driver education, enabling novice drivers to be confronted with ranges of risky situations rarely encountered in natural environments and help them to become aware of their skills when faced with unusual potential situations.

Keywords – simulation, driving experience, accidents scenario
References


Sleep related car crashes: risk perception and sleepiness at wheel coping strategy

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Abstract
Sleepiness is often a contributing factor in car crashes [1]. Drivers under 30 years of age are particularly prone to sleep-related accidents in the early morning [2]. Despite the growing body of evidence indicating that young novice drivers are an at-risk population for nocturnal car accidents caused by sleepiness, they often underestimate potential hazards in the environment and overestimate their driving ability [3].

Some studies have focused on the analysis of coping strategies for sleepiness: young drivers usually refer they can remain alert during times of endogenous pressure for sleep by means of an attentive compensatory effort, even if data indicate that this strategy does not succeed in avoiding periods of poor, inefficient and variable performance [4].

The aim of the present study is to examine which factors are associated with the risk perception to have night-time car crash in young drivers and to evaluate the strategies most commonly used to counteract sleepiness at the wheels.

1123 young drivers (41.8 % males) with an age between 18 and 25 years (mean=21.04, SD=1.65), with at least 6 months driving experience participated to the study. A questionnaire was individually administered to each participant during face-to-face interviews. The questionnaire was composed of two different sections respectively concerning

1) Questions about night-time driving and the related risk perceptions
2) Questions about previous experience of sleepiness at the wheels and about the strategies used to cope with it.

A linear regression analysis pointed out that males are less worried about night-time car crashes than females (β=.07). Such concerns decrease with the increasing of night-time driving (β=-.12), whereas the frequency of episodes of driving impaired by sleepiness increase the perception of this risk (β=.14).

With regard of the coping strategies for counteracting a sudden sleepiness attack at the wheels, 51.47% of the participants answered that they “would continue driving but do something in order to cope with the problem”. The behaviours that they would adopt in order to cope with the problem of excessive sleepiness when driving at night are:” Opening windows” (18.10%), “Increasing the effort and attention” (13.25%), “Increasing radio volume” (12.75%), “Singing” (9.7%), “Decreasing the speed” (5.3%), “Stop and taking a...
coffee” (13.20%), “Stop and washing the face” (10.19%), “Stop and taking a nap”(7.7%), “Stop and walking”(5.84%).

A logistic regression analysis showed that the risky decision to continue driving while impaired by sleepiness is positively and linearly related to the frequency of night-time driving(Wald= 15.40, gl=2; p<.001).

Our results indicated that the frequency of night-time driving influences risk perception and worries: the perceived likelihood of having a sleep-related car crash and the counteract sleepiness with safe strategies are lower for those who report driving at night more frequently. This result appears paradoxical, but several studies indicate a similar correlation between perception of risk and the frequency of involvement in risky behaviour among adolescents [5].

**Keywords** – pavement, PMS, selection, implementation, performance, cracking, sensitivity

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**References**


Driving and activation of mental concepts

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Abstract
Safe driving depends on the amount of how the driver is able to build up an appropriate dynamic representation of the traffic environment.

As shown by several studies, not the number of details within this representation is the deciding factor, but the representation of some single aspects which are of high relevance [1; 2]. This leads to the consideration that mental representations which were built up during driving consist of a dynamic series of activated concepts. It is assumed that the concepts are activated by salient stimuli which occur within the traffic scenario. By definition, salient stimuli are those which attract attention. As could be shown by an own study in which eye-movements were recorded, dynamic stimuli as well as living objects automatically attract attention [3].

To investigate to which amount activated concepts influence driving behaviour, a driving simulator-study was performed. Therefore a series of 8 different traffic scenes was constructed which were presented under two conditions. In one condition salient stimuli were displayed (e.g. pedestrians at the roadside) before an event emerged (e.g. a pedestrian emerging behind a bus) which shares the same concept (pedestrian). In the other condition the event emerged without showing a related stimulus before. It was expected that under conditions in which corresponding concepts are activated, drivers respond much faster to emerging events.
30 subjects took part in the experiment and were assigned to one of the experimental conditions. Response latencies and breaking behaviour data to emerging events were collected. For checking whether the stimuli which should activate the concepts attract attention, eye-movements were recorded via a SMI eye-tracker.

The results showed that subjects responded faster to emerging events if corresponding concepts were activated before. But concepts are only activated if the event related stimuli shown before attract attention. In such cases breaking behaviour was also more effective. Thus mental activities during driving can be understood as a sequence of activated concepts triggered by salient stimuli of the traffic scene. The implications of this point of view are discussed with respect to effects of interfering activated concepts and their consequences to driving behaviour.

Keywords – salient stimuli, attention, mental concept, braking behaviour, eye-movements
References


Effect of simulator training on driving after stroke

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Abstract

Driving performance is impaired by problems such as motor, visual, cognitive and perceptual deficits that are commonly experienced after stroke. Despite those deficits, some stroke patients seem to benefit from driving training programs.

Our goal was to investigate the effect of simulator-based training on driving after stroke [1]. In this randomized controlled trial (RCT), eighty-three first-ever subacute stroke patients entered a 5-week 15-hour training program in which they were randomly allocated to either an experimental or control group. Subjects in the experimental group received simulator-based driving therapy. After driving a 5-km familiarization scenario, subjects’ driving performance was evaluated on pretraining assessment of 13.5 km. number of collisions, pedestrians hit, excessive speed, traffic light faults, total faults, and run-time were recorded. Based on the outcome of the pretraining scenario, simulator training progressed by exposing subjects to a variety of 5-km training scenarios containing different but common traffic demands. The training scenarios involved recognizing traffic signs, executing overtaking maneuvers, driving through complex points, and merging into new lanes. Subjects in the control group received standardized training by performing driving-related cognitive tasks such as route finding, memory training, and recognizing traffic signs and situations.

Performance in off-road evaluations and an on-road test were used to assess the driving ability of subjects pre- and post-training. The off-road evaluation involved descriptive measures, evaluation of visual acuity, kinetic vision, useful field of view (UFOV), and component tests of the Stroke Driver Screening Assessment (SDSA). A valid and reliable on-road test was performed in a car adapted to the physical needs of the patient. Outcome of an official pre-driving assessment into three categories (i.e. “fit to drive,” “temporarily unfit to drive,” and “unfit to drive”) administered 6-9 months post-stroke was also considered.

Both groups significantly improved in a visual and many neuropsychological evaluations and in the on-road test after training.

There were no significant differences between both groups in improvements from pre- to post-training except in the “road sign recognition test” of the SDSA in which the experimental subjects improved more. Significant improvements in the three-class decision (“fit to drive,” “temporarily unfit to drive,” and “unfit to drive”) were found in favour of the experimental group post-training. Academic qualification and overall disability together determined subjects that benefited most from the simulator-based driving training. Significantly more experimental subjects (73%) than control subjects (42%) passed the follow-up official pre-driving assessment and were legally allowed to resume driving.
We can conclude that simulator-based driving training improved driving ability, especially for the well-educated and less disabled stroke patients. However, the findings might be modified as a result of a large number of dropouts and the possibility of some neurologic recovery unrelated to training.

Keywords – cerebrovascular accident, rehabilitation, driving simulator training, cognitive training, randomized controlled trial

References
Driving situations expected by drivers in relation with their cognitive categories of urban streets

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Abstract

While human factors are involved in the major part of accidents, in depth analyses of accidents processes stress the influence of environment and road design on drivers' behaviour [1]. These results suggest that drivers' behaviour could be modified by acting on road design. Thus, it implies that road engineers need to know how drivers use environment information in driving activity so that they could take it into account in road design.

This paper presents a research we have carried out, involving engineers and psychologists, in order to tackle this question.

According to cognitive psychology models, human beings manage with the quantity and complexity of the information they perceive by segmenting the world into categories [2]. They consider the components of the categories as being similar. Therefore processing information from the environment, analysing a situation, is based on identifying the relevant category. Previous researches have shown that this way of operating is used in driving activity [3]. Drivers organise their knowledge on road environments and driving situations in categories they use to diagnoses a situation and adapt their behaviour. They associate to these categories some events they expect to encounter [4]. Given the multiplicity of information, of driving situations and the dynamic constraints of this activity, the adapted and safe behaviours require the effectiveness of such a cognitive process. A good understanding and anticipation of driving situations depends on the categorisation of the road by drivers and the events they expect in this category.

Our research was aimed at identifying the drivers' categories of urban streets and the driving situations they expect in each category.

The experimental procedure [5] consisted at first in asking experienced drivers to classify photos of urban streets, grouping together the streets in which they expect the same kind of situations. Then the drivers were asked to explain their classification. A compromise (a median classification) between all the classifications of the drivers-subjects was constructed using a median partition procedure based on linear programming techniques. These classes which are a reflection of general categories of drivers as a whole were interpreted through the subjects' verbalisation.

This paper focuses on drivers' expectancies in the different street categories that they use in processing information from driving environment.
The subjects expressed very freely and precisely the situations they expect in each category (pedestrian crossing, pedestrian walking along, vehicle leaving parking, etc…). Their expectancies appear to be very specific to the category. They also depend on the context of driving such as the period of the day.

**Keywords – anticipation, categorisation, cognitive psychology, street design, road safety**

References

Useful field of vision and peripheral reaction time in novice drivers – transfer to a real driving situation after a perceptual-motor training program

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Abstract

Visual stimuli detection is crucial for the accomplishment of the great majority of daily tasks, as well as for sport and professional activities.

Driving, as a highly complex perceptual-motor task, is also very dependent from a good visual perception.

Besides the need of central stimuli detection (e.g., to keep a safe distance for the front vehicle), it is also important to detect peripheral stimuli (e.g., to detect in advance children who cross the road unexpectedly).

One of the major causes of accidents in youngsters is distraction [1]. Driving has a lot of potentially distracting situations, and it looks that many persons have difficulties dealing with simultaneous events. Driving performance can deteriorate and become potentially dangerous when someone pays attention to a secondary task at the expenses of the attention needed to the main driving task.

Literature gives us several examples of better peripheral vision of people engaged in sports compared to those who are not [2] and, probably, some advantage in certain aspects of driving performance [3].

In previous studies [4; 5]) we could verify that young female basketball players were better on dividing attention than non-player females, in a simulated perceptual driving task. These results supported, at least partially, our assumption that there could be some sort of transfer between some sport activity and driving features, namely at the peripheral vision/useful field of vision level.

We could also verify that peripheral vision and speed of reaction were trainable, that is, were not built up with people but could improve. We tested non-player females and, after that, submitted half of them to a Useful Field of Vision and Peripheral Reaction Time Training Program (UFVPRTTP). Since the experimental group improved significantly more than the control one, we concluded that the differences found in the previous studies were not, probably, due to already existing differences between players and non-players but to increments in visual performance that resulted from team sport practice. We should remark that, in these studies, subjects had no driving license or experience of driving.
Now, in this study, we wanted to verify if there were differences on the capacity of novice drivers to detect peripheral lights that appeared randomly inside the car, at the left or right over the front panel, while driving in a closed circuit. To force them to divide attention, there were several marks in the pavement they had to pass over. Subjects were team sport players and non-players. In this study, an experimental group of the non-players was submitted to the UFVPRTTP. We intend to verify if the experimental group will improve significantly more than the control one.

The preliminary results show us that team players surpassed in a significant way non-players in the number of detected peripheral stimuli, though there were no significant differences on the peripheral reaction time. We have already began to train non-players experimental group on dividing attention between central and peripheral tasks, at the gym, and hope that within a month, when the Training Program finishes, we can conclude that it is possible to train (young) people to develop skills that will help them to diminish the probability of having accidents based on distraction or lack of ability to divide attention between central and peripheral tasks.

Keywords – peripheral vision, peripheral reaction time, divided attention, novice drivers, team sport-players

References

Validity of driving simulator in assessing ability of drivers with Parkinson disease

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Abstract

Background and objective:
Clinical symptoms of Parkinson Disease (PD) can make driving hazardous [1; 2; 3]. This paper aims at exploring the validity of using driving simulator technology in assessing drivers with PD and highlighting the possibility of using such technology clinically to improve assessment and on-road safety of such population.

Method:
Fifty three idiopathic PD and 129 age matched controls were assessed by driver trained occupational therapist and driving instructor in open roads and the STISIM driving simulator. Prior to the driving assessments, PD participants were screened medically by a geriatrician. Scores from specific driving tasks were aggregated to a composite score representing overall driving performance of participants. Multivariate analysis was employed to explore the effects of independent variables of driving tasks.

Results:
The driving performance of the participants was confirmed to be negatively associated with age (r between 0.79 to 0.89, p<0.001). Drivers with PD are significantly less competent drivers than controls, as reflected by lower simulated driving performance scores (t180 = 104.6; p<0.001) and lower on-road scores (t180 = 84.2; p<0.001). The commonest errors committed on the road were failing to check the blind spot appropriately, signalling inappropriately to exit roundabouts, and reduced usage of rear view and side mirrors. The performance of participants recorded by the occupational therapist and driving instructor were highly correlated (r = 0.86, p<0.001). After adjustment for age and gender, 49% of the variability of the on-road performance can be explained by the simulated driving performance in the PD group (F (3,48) = 6.87, p-value < 0.001, R2 = 0.491), whereas in control group, 68% was explained (F (3, 125) = 82.75, p-value < 0.001, R2 = 0.675).

Conclusion:
The study concluded that PD drivers are significantly less competent drivers than the age matched control group. The driving simulator reflected less true driving performance in the PD group then in normal older adult population [4]. In a disease group, the lower reflection is not surprising. The simulator technology has the potential to be used in screening of unsafe PD drivers [5].

Keywords – driving simulator, Parkinson’s disease, assessment
References

Simulator based in-car system evaluation with older adults

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Abstract

The motivations and preferences of different user groups for are important when designing in-car electronic systems. This paper examines the part that context plays in the evaluation of a speech based in-car messaging system when tested with older adults. Technology developers when designing for all, including older adults, should be aware of the preferences of different user groups. There exist today instances of technology which could be of great benefit to older people where unfortunately uptake is mainly by the young. In-car message systems for example, under discussion in this paper, are available in many cars and could be of value to older people for orientation and help with driving. However they are under used by this age group.

The authors have run several tests using a SISTIM Driving Simulator to determine older adults’ preferences with in-car speech systems including attitudes and attention [1]voice age preferences [2], emotion in voice [3], use of a ‘Virtual Passenger’ and many more. These were also investigated in conjunction with driver safety measures provided by the simulator.

This paper explores how age related changes affect those facilities required for successful in-car technology use and discusses why evaluation of the systems creates new challenges. In particular the paper looks at the way in which older people have different perceptions from younger people [4] and are more sensitive to change of context when evaluating systems [5].

Previous experiments using the STISIM Driving Simulator to represent a driving scenario with in-car speech messages showed considerable difference in the preference of voice type between younger and older people [2].

This paper describes experiments using a laptop computer rather than a driving simulator aimed at finding out more about what affects the acceptance of the voice that is used. Significantly, the results concerning voice perception by older adults derived from the laptop experiments contradict those derived from the driving simulator experiments.

Older people are considerably influenced by the context in which evaluation takes place and in fact produced different evaluations of speech messages when they are heard on a laptop compared with within a simulated driving scenario.

Younger people were far more consistent in their evaluation under both conditions, and less influenced by the change in context. These results reveal the complexity entailed when designing in-car speech systems which include older people, and point to the need for extra care when testing in-car system with older people where the context of use is different from real world driving.

Keywords – older adults, in-car speech systems, driving safety, user preference, context
References


2. Jonsson, I-M., Zajicek, M., Harris, H., Nass, C., 2005, Thank you I did not see that: In-car Speech-Based Information Systems for Older Adults, Proceedings of CHI 2005, Portland, OR


5. Zajicek M, Jonsson I, 2007, A Complex Relationship, Older People and In-Car Message System Evaluation, Gerontechnology, 6(2)
On-road and laboratory evaluation of bilingual variable message sign

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Abstract

The purpose of this study was to determine how best to accommodate bilingual signing on freeway variable message signs (VMS). The first phase involved an on-road test of how well drivers could report messages after passing by English-only VMS. Drivers were then tested using similar VMS messages, in the laboratory. The messages were displayed using progressively shorter intervals. Performance in the laboratory was similar to on-road when the display interval was 4 seconds. This display interval was then used to assess bilingual alternative versions of the English messages.

Two bilingual versions were compared to the English-only version. The first (3L) used 3 lines of text with pictograms at each side. English appeared on the first line and half of the second line, followed by a divider, and then the French message. The pictograms presented the same information but in a graphical format. The second alternative (4L) used the top 2 lines for the English message and the next 2 lines for the French message. No pictographs were used. The 3 line version could be implemented on current VMS; the 4 line version would require replacement of all signs.

Laboratory testing was carried out with 90 anglophones and 45 francophones. There were three age groups: under 25, 25 to 55, and over 55 years of age; half of the subjects were male, and half female.

The VMS results indicated that there was no significant difference in performance between English and French for the 4L signs or for the English only signs. However, the French performed significantly worse than the English on the 3L signs.

For both English and French subjects, using colour (to indicate degrees of congestion), on the 3L sign helped improve performance more than adding it on the 4L sign (where it was used to differentiate English (white) and French (yellow)), though the effect was a very weak trend, and not significant.

Overall, on VMS messages, French subjects performed significantly more poorly than English subjects on all three formats, both in terms of average scores on information transmission and comprehension as well as in numbers of completely missed messages. This poorer performance was in all likelihood associated with the fact that one-third of the signs were presented in English only, and in the bilingual alternatives, English was in the position of priority (top and left) which is read first. The 3L sign is likely more difficult for French subjects than the 4L sign because the two languages are less clearly spatially separated and are not colour separated.

Sign comprehension was scored out of 3. Mean comprehension for English subjects was 2.25, and for French subjects, 1.99. Where 3 units of information were transmitted, English subjects retained 1.78 units on
average and French subjects, 1.53 units on average (1 unit of information answers a “what happened”, “where” etc. question). The information in the first line was generally the best transmitted.

Several pictograms were tested. Where pictograms were used without text redundancy, subjects did not report the information contained in the pictogram (e.g., ramp to express, centre lanes, express very slow). Despite the lack of reporting of some sign elements, comprehension was generally good.

*Keywords – bilingual signs, driver comprehension, message length*
Visual perception and response behavior
by driving simulator and eye tracking system

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Abstract
It is important for a driver who drives an automobile safely to perceive hazard in advance [1; 2] which is
called generically as several factors inducing accidents in a traffic situation. The hazard perception is needed
the function to take on hazard information at early stage [3; 4], and the most of necessary information is
obtained from information processing ability and visual attention [5]. Therefore it is useful to analyze the
relationship between the feature of eye movement and road scene. For this aim it is studied in the paper by
using the driving simulator and the eye tracking system.

An experimental paradigm is performed for the measurement of time histories of eye movements during the
driving by simulator.

The experimental system proposed in this paper is able to realize the situation of driving and analyses of
human factor for awareness of hazard or risk. Another aims of this work is also to offer the knowledge for
hazard information by relevance between several traffic situations and human factors in order to forecast a
human behavior such as visual attention during driving work. It is studied that the relation of visual attention
and histories of vision motion by the eye tracking system during driving work on the simulator
experimentally.

A head-mounted eye tracking system (SR Research EyeLink II) with an accuracy of 0.58 and sampling at
250 Hz is utilized in order to record the eye movements, which are able to impose on video recordings
driving scene where the coordinates of attention point of driver on the front side scene can be recorded by
the time series data.

The automobile driving simulator (DA-D00, Honda Motor Co., Ltd) is implemented an advanced 6-axis
motion base (sway-motion device) that closely approximates vehicle dynamics in real world situations to
provide driver trainees with instruction in safe driving techniques. In the paper, eye movements and road
scenes are taken into account from a moving driver’s perspective. The relationship between the feature of
eye movement and road scene are also investigated. This result enables one to investigate the difference of
eye movement on the traffic situation. For examples, it was shown that the histories of eye movement were
strongly dependent on the road condition such as normal road with passing, rainy slipping road and snow load.

The experimental system proposed in this paper is useful for the simulation of safety driving and analyses of human factor for awareness of hazard or risk. Another aims of this work is also to offer the knowledge for hazard information by relevance between several traffic situations and human factors in order to forecast a human behavior such as visual attention during driving work experimentally. It is studied that the relation of visual attention and histories of vision moving by the eye tracking system during driving work on the simulator.

**Keywords – response time, eye tracking system, driving simulator, visual perception**

### References

Effects of age in useful field of view and time-to-arrival

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Abstract
Visual Attention and Speed Perception are important abilities for safe driving through all ages 1,3. Nevertheless, many studies that investigate age effects on driving capability frequently centre the scope of research in older adults or just compare them with young adults, omitting the middle-age drivers and consequently making difficult to understand the abilities evolution across the lifespan.

The main aim of this study was to investigate age effects in Useful Field of View (UFOV) and Time to Arrival (TTA). Ninety-six male and female active drivers participated in this study: 32 young drivers (18-30 years), 32 middle-aged drivers (38-50 years) and 32 older drivers (60-75 years).

The three subtests of UFOV®, reviewed as a valid and reliable index of driving performance and safety2, were administered to measure speed of visual processing, divided attention and selective attention. TTA was studied with a removal paradigm, using two vehicle speeds (50 and 70km/h) for data collection. Accuracy in performance (absolute error, AE), response bias (constant error, CE) and response consistency (variable error, VE) were registered.

To assemble information regarding driving habits, a short questionnaire was applied. Visual Acuity was measured with a Snellen Chart. Cognitive status of older drivers was evaluated using the Mini-Mental State Examination.

Results showed that compared with young and middle-aged drivers, older drivers had poorer results in divided attention and selective attention. Also for divided and selective attention, data has some nonlinear variation revealing a decrease in visual attention performance much more evident from the middle-aged to the older group then from the younger to the middle-aged group.

In TTA analysis, older adults had greater VE judging a vehicle approaching at 50km/h when compared with young and middle-aged drivers. Although not significant, it is also interesting to notice that middle-aged drivers had greater CE and young and older drivers had lower and very similar CE, showing up an inverted U-shape relationship between age and CE of TTA.

Partial correlation coefficient controlling for visual acuity affects, revealed two low associations between UFOV and TTA: greater VE judging a car approaching at 50km/h were associated with worse scores in
selective attention and divided attention. The modest relationship founded between the two abilities is in agreement with Raghuram & Lakshminarayanan4.

Comparing error measures between two velocity paradigms used in TTA, differences were established between CE and AE when the approaching vehicle speed was 50 km/h and 70 km/h, respectively. These results showed that TTA estimated accuracy increased when the approaching vehicle travels at higher speeds.

We conclude that Visual Attention measured by UFOV® seems to be more sensitive to age effects than Speed Perception measured by TTA. Moreover, the significant losses detected only occur in older drivers. This conclusion has implications in design interventions to enhance those capabilities.

Simultaneously, correlations between UFOV and TTA were low, suggesting that probably they measure different aspects of visual information processing. This is in agreement with different rates of loss founded for Visual Attention and Speed Perception. It seems that TTA could be relevant measuring specific aspects of visual information processing in addition to other instruments like UFOV®.

Keywords – driving, aging, visual attention, time-to-arrival

References
A simulator for assessing older driver skills

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Abstract

This paper describes analysis of 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 [1]. The simulator performance results show sensitivity to age, and do not appear to be affected by simulator sickness symptoms [2].

The driving simulator performance measures from a total of 118 participants, comprised of 67 older drivers (aged 70-90; 37 male, 30 female) and 51 younger drivers (age 21-50; 22 male, 29 female) are presented.

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.

Performance measures for a total of 9 scenario designs are discussed. Results indicate that continuous variable measures (e.g., vehicle speed, vehicle to road curvature deviations, and time-to-collision measures) are more sensitive than discrete event measures (e.g., collisions) in discriminating older from younger drivers. Implications for driving simulator scenario design for older driver assessment are discussed and recommendations are provided.

Simulator sickness (SS) ratings were also obtained as part of the assessment process. SS is a significant problem with older subjects and in particular with older females. Sickness ratings after each of 5 driving simulator sessions were obtained using the Kennedy, Lane, et al. Simulator Sickness Questionnaire (SSQ).

Consistent with the literature, results suggest a higher incidence and prevalence of simulator sickness for older drivers and for the female gender. However, it was found that SS did not influence performance measures, which is a key issue in using driving simulation for assessment.

The paper also provides an overview of the test battery and driving scenarios designed to address simulator sickness prone individuals.

Keywords – driver behaviour, older driver, driving simulation, simulator sickness
References


Using a riding trainer as a tool to improve hazard perception and awareness in teenagers

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on behalf of Honda Riding Trainer-Psychological Evaluation

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Abstract

Previous studies suggested that important factors in avoiding an accident are related to decision making and motor skills. The research also showed that hazard perception training in novice drivers leads to improved performance on hazard perception tests \citep{2, 3, 4}. It is still controversial whether such training will, in the long run, actually result in safer drive behaviour and in fewer crashes. Hazard perception training may be even more critical for riders, as motorcyclists are not protected by a vehicle body so the ability to perceive and respond to hazards posed by other vehicles is crucially important \citep{1}.

This study is aimed to find out whether a rider simulator (Honda Riding Trainer, HRT) could improve the hazard perception and awareness in teenagers. The HRT presents a number of training situations with various training modes for different environments. HRT allows to safely experience hazards by offering twelve evaluated tracks where each track presents eight hazard situations. On-screen the rider sees and hears a realistic three-dimensional world.

The experimental procedure involves a pre/post randomized experimental design with an experimental group (A) and a control group (B), both of 200 participants randomly assigned. The order of track presentation to subjects was randomized by latin square technique, allowing each track to be presented with the same frequency in all the order positions. Subjects are 14 to 15 years old students, enrolled during their first year of secondary school in North-East of Italy.

Between the pre- and the post-tests, Group A undergoes a whole training with HRT in three sessions (one hour each), whereas Group B undergoes a traditional training (i.e., frontal lessons concerned with risk-perception, for about the same time).

The setting is a schoolroom lit by natural light, each student is supported by an instructor, who also assists to the experimental sessions.

Results show a clearly visible learning process an improvement in students’ performance, regardless of the order in which the tracks are presented, trainees improve their performance with HRT. Pre-Post test analysis by comparing differences in accident frequencies occurring in pre-test compared to post-test confirmed a significant difference exists between number of accidents pre-test and post-test. This difference shows a decreasing number of accidents related to increasing HRT practice.
Moreover at post-test participants’ hazard awareness in the experimental condition is higher than in the control condition.

**Keywords** – hazard perception, awareness, trainer, improvement

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**References**

Friday 9th November 2007
Time 9:00 am
Session C1
Driving simulation: road design

Chaiman – Mr. Maurizio Crispino
RSIT - knowledge-based support of high-crash site investigation

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Abstract

Road intersections and segments identify and as experiencing high number of crashes are investigated to identify roadway and traffic control deficiencies and relevant safety countermeasures. Site investigators must rely on their experience and judgment which may be an overwhelming task to those who lack such an experience.

This paper presents a concept of a tool, called Road Site Investigation Tool (RSIT), that assists less experienced investigators as well as saves time of more experienced ones.

A prototype of the tool developed for two-way stop-controlled intersections is introduced and evaluated. The RSIT includes two components: (1) an editable knowledge base that can be easily updated or modified by a user to fit his needs, and (2) a user interface that accesses the knowledge base, organizes a site investigation, and documents the investigation findings.

A knowledge base is represented in the form of a tree, where branches form sequences of checks (nodes) leading to specific countermeasures. There are two types of nodes: classification nodes and condition nodes. The classification nodes are merely needed to advance and organize the investigation while the condition nodes are necessary for a selected countermeasure to be justified. This distinction becomes important in estimating uncertainty in the investigation results to rank the selected countermeasures for implementation. The knowledge base for two-way stop-controlled intersections was acquired from several guidelines and manuals for road safety audits: NCHRP Synthesis 336 Series, NCHRP Report 500 Series, NCHRP Report 457, and other [1,2,3,4]. To document and edit the knowledge base, the public-domain tree editor HDS was used. A graphical user interface (GUI) was developed to facilitate the knowledge base application to site investigations. It has several functions for guiding the user through the investigation and documenting the outcome:

1. reading the user-defined or user-edited knowledge base,
2. displaying the current set of questions,
3. prompting the answers selected so far,
4. prompting possible next questions based on the answers already given,
5. allowing writing comments by the investigator, and
6. preparing a report summarizing the investigation.

The proposed method has been evaluated to verify its usefulness. The evaluation compared findings obtained at the same locations by an experienced team with the standard method of road safety investigations and by several groups of “non-experts” equipped with RSIT. The evaluation criteria of the method included consistency and validity of the identified roadway deficiencies and efficiency of the method. The evaluation
revealed that the knowledge structure and functionality of the GUI are easy to understand even to non-experts. The time spent on the investigation process with RSIT was shorter than with the traditional safety audit.

The results of the two teams of experts and non-experts equipped with RSIT were similar although not identical.

The future development process should include extension of the existing knowledge for signalized intersections, four-way stop-controlled intersection, road segments, and railroad crossings.

Keywords – safety audit, investigation, knowledge base, road improvements, countermeasures.

References

A methodology for setting speed limits for Greek roads

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Abstract

The simplest approach for controlling operating speeds on a roadway is through the use of posted speed limits. An international common practice is to set speed limits at the 85\textsuperscript{th} percentile of operating speeds (V85). There is a suspicion however that operating speeds are often controlled by the roadway geometry and environment. The various geometric related features of the roadway are a result of the design speed chosen. There is therefore an implicit assumption that there is an agreement between operating and design speeds. However, this often is not the case. Moreover, posting of speed limits based on operating speeds that are inconsistent with design speed can create potential safety problems. Posted speed limits that are higher than the design speed of the roadway may also have a safety impact. The development and establishment of a proper methodology for determining the appropriate recommended speed limits is therefore imperative in improving both operational and safety efficiency of a roadway segment. A systematic effort was undertaken recently to develop a set of guidelines for establishing procedures for recommended speed limits for Greek roadways.

The study reviewed international practices in Europe, USA, and Australia, and developed a set of procedures to be followed when considering the establishment of appropriate speed limits. The review focused in understanding the issues relative to posted speeds and examined their relationship and impact on safety. The procedures examined assisted in identifying the problems as they relate to safety and operational performance of a roadway and aided in the development of the Greek guidelines. An opinion survey of car and truck drivers was also completed to determine their attitudes and behavior toward existing speed limits and record any previous crash involvement.

The results indicate that a significant number of drivers exceed the current posted speeds, there were no differences among the various age groups of drivers, and few drivers have been involved in a crash. As expected, the major reason for not obeying speed limits is that the limits are not reflective of the roadway conditions and most drivers feel that they are lower than what the roadway can accommodate. This coincides with the assumption that the operating speed is more likely to be influenced by the roadway features rather than the speed limits or design speed. The results were similar for drivers of both passenger cars and trucks.

However, comparisons between local drivers and non-local drivers showed that local drivers are often those who violate the existing speeds, most likely due to familiarity with the roadway features.

Keywords – operating speeds, driver behavior, speed limits
Risk-based approach for highway geometric design

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Abstract

The satisfaction of sight distance on road sections is one of the main design bases that are used to design horizontal and vertical curves.

Designers have to enable road users to see enough distance ahead to execute appropriate actions and maneuvers required for safe and efficient travel. This distance might be restricted by the road surface, side slopes, lateral obstructions, and/or vertical overpasses. In calculating the sight distance actually available for drivers on a specific highway alignment, the current design practice utilizes a two-dimensional (2D) approach based on separate horizontal and vertical highway projections. Assuming a little effect of the third dimension, this approach is fairly simple and is widely used in almost all design guides worldwide.

Recent research has shown, however, that a three-dimensional (3D) approach considering the overlap between horizontal and vertical alignments should be adopted as a more precise one.

As stated in the AASHTO Green Book [1], the available distance should be at least equal to the required stopping sight distance (SSD) while longer distances are recommended wherever practical. Using the laws of kinematics, the SSD was formulated in terms of the vehicle speed, longitudinal acceleration, driver perception and reaction time, and longitudinal grade [1; 2]. Percentile values are then recommended for these design parameters to predict the minimum required SSD. Excluding the longitudinal grade, these parameters vary from time to time and from one driver to the other. Subsequently, choosing a near-worst value for each parameter to calculate a single design value may lead to unrealistic results. On this, Fambro et al. argued

“individual model parameters have been criticized as representative of drivers that do not exist; objects that do not exist and cannot be seen; and an assumed braking condition that does not exist, is unsafe, and not representative of real-world driver behavior” [2].

This paper therefore addresses the task of reconciling the variability in both required and available SSD, resulting from the variability in the design parameters, to develop a probabilistic design approach in contrast with the deterministic approach in current guides. Such a probabilistic approach will utilize the reliability analysis to calculate the probability of hazard, which is equal to the probability of a driver having a required SSD greater than what is actually available. In addition, a reliability index can be calculated to indicate the level of safety provided by the alignment.

In this paper, the steps required to develop a probabilistic design approach will be presented for the case of SSD. As a first step, an application example is presented to consider the variability of available SSD in both 2D and 3D analyses.
Therefore, the application example should show the difference between the deterministic and probabilistic approaches, and will also show the difference between the 2D and 3D analyses.

Keywords – highway design, sight distance, reliability analysis

References

Driver perceived discomfort and road safety

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Abstract

Road geometry and traffic conditions strongly influence the drivers behaviour. It does not happen for any other engineering constructions.

The authors propose a model for the evaluation of a discomfort level (DL) locally induced by different road environment and traffic flow conditions.

The main theoretical hypothesis behind the model is that a significant indicator of the discomfort level is computed as proportional to the difference between driver’s desired speed (Sd) and the average travel speed (St) imposed by local traffic density. To evaluate the level of discomfort of a homogeneous road segment, the variation of road characteristics and traffic conditions in terms of flow and composition must be taken into account. Moreover driver’s desired speed depends on the individual reason of the travel. Therefore, considering a traffic condition, the level of discomfort in a specific road location will assume different value for each flow typology in terms of travel motivation. The greater the difference between desired speed and flow speed, the higher the discomfort level.

Twenty-five Italian rural two-lane road segments (each homogeneous segment is 20 km long) have been analysed to represent different traffic, road and environmental conditions. Data requirements were divided into four main categories: roadway and environmental characteristics, traffic conditions (including percentage composition of traffic flow), average travel speed and accidents data. Field survey was needed for data collection. The discrepancies between drivers expectations and operating conditions have been analysed. These data have been correlated with road dependent collisions of each road segment.

This paper shows the results and points out the validity and applicability of the model to actual case studies for the evaluation of the expected accident occurrence of a road segment as a function of the DL suffered by road users in the same segment.

Keywords – discomfort, risk threshold, driver’s behavior, road dependent collisions, roadway and traffic conditions

References


Friday 9th November 2007
Time 9:00 am
Session G1
Infrastructure engineering, human behaviour and vehicle technology

Chairman – Mr. Jarkko Valtonen
Abstract
The objective of SUPREME (Summary and Publication of Best Practices in Road Safety in the Member States) was to collect, analyse, summarise and publish best practices in road safety in the Member States of the European Union (EU25), Switzerland and Norway, with a view to implementation in as many partner states as possible. By making the study results available to a broad target audience across Europe – and thereby encouraging the take-up of successful strategies – the project shall contribute to reaching the 50% reduction target of road fatalities, which the European Commission set in its White Paper "European transport policy for 2010: time to decide" (2001). SUPREME was funded by the European Commission, DG Energy & Transport.

The crucial task of the project lies with the sound identification of best practice from the vast amount of available measures.

In order to facilitate this process, a set of tools for classification, selection and ranking of measures was developed, along with guidelines for the assessment process at country level. On this basis, a network of Country Experts gathered information from various stakeholders. In total, 228 questionnaires have been completed for each measure considered suitable to be included in the SUPREME framework.

Analysis, synthesis and further selection of collected data was carried out along 9 categories of measures (covering all areas of road safety work), each of them led by a partner with outstanding experience in the specific field (Analysis Group). A set of 8 criteria has been developed to assess the proposed measures against effectiveness and transferability, sustainability and public acceptance. Thematic reports have given a detailed description of best available practices for each of these categories, featuring basic characteristics such as target groups, quantitative and qualitative goals, key issues, duration of implementation and effects, coverage, costs, actors involved, implementation procedures. These results have been given a second stage of feedback from the country experts and involvement of organisations at European and international level on order to identify key success factors and potential implementation barriers in other countries or at the European level.

The results have been synthesized into 3 core products.

The "Handbook for measures at national level" addresses road safety measures, which can be implemented at national level.
The "Handbook for measures at European level" focuses on measures which require the European level for implementation.

A technical report summarizes the process of identification and results and experiences made during collection, analysis and selection of measures. Three additional papers include information on applied examples in the SUPREME partner countries, experiences made during their implementation and later, barriers which had to be overcome, efforts for dissemination of best practices and a list of all proposed measures.

SUPREME has created a selection of road safety measures which have been assessed carefully and receive strong acceptance from stakeholders at all levels. Criteria for best practice will be discussed. A brief overview on the process and practical experiences with this approach will be given as well as on the results, i.e. best practices identified in the nine categories. Finally, for a selection of best practices, key success factors and potential barriers will be addressed.

**Keywords** – road safety, best practice, measures, assessment sensitivity

**References**

2. Weber (edit.), "ROSE25: Inventory and compiling of a European good practice guide on road safety education targeted at young people", European Commission, Brussels, 2005
Human Factors in road infrastructure design: analysis of road layout influence in driver behaviour

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Abstract

When road safety is analysed, three different areas of action can be defined corresponding to the three main actors involved in road safety: human, vehicle and infrastructure (“the three safety pillars”). In this context, the European Project RANKERS (RANKing for European Road Safety) [1] pursues the ambitious objective of developing scientifically-researched guidelines aimed to promote safer roads and eradicate dangerous sections. It aims to gain new knowledge by performing empirical studies of the road’s interaction with the driver and his vehicle in order to identify optimal recommendations and predict their safety impact. As a result, an index to assess and monitor road safety and a comprehensive catalogue of ranked road infrastructure safety recommendations will be produced at the end of the project.

This paper presents one of the studies carried out within RANKERS project, focusing on road-driver interaction and its impact on road infrastructure design, particularly addressing road layout influence on driver behaviour. Existing literature reveals the influence of road environment characteristics on driver behaviour [2] and the strong relationship between speed and safety on the collective traffic level [3]. Speed is generally a key variable in road infrastructure studies, since the perception and choice of travel speed is highly connected to the particular road environment and driving context. The most consistent road feature associated with the rate of single vehicle road accidents is road layout, mainly horizontal curvature. In many instances, an increase in run-off-the-road accidents has been attributed to a decrease in the radius of curvature [4; 5]. Similarly, relationships have also been found between crash rate and degree of curvature. The frequency of curves do not seem to influence to crash rate directly, although there is some suggestion that an unexpected sharp curve may be accident inducing and that the geometry preceding the curve may also influence subsequent curve negotiation [4; 5].

Therefore, the objective of this study is to analyse the speed variation as a function of curvature and trying to focus on questions such as: How do drivers approach a curve (at which speeds)? When do they start to react to it, either braking or releasing the gas pedal? How do they behave along the curve (curve negotiation)?

A field test method was carried out in real road conditions in a mountainous motorway (AP-66) in the north of Spain with an instrumented vehicle in order to record on-board vehicle measures (video techniques and devices for gathering behavioural data) and collect remarkable events observed during the driving session. The observations are directly guided by hypotheses about certain psychological processes that could explain the way drivers interact with the road environment, in this case, guided by drivers’ expectations in relation to road layout. A sample of 32 drivers, balanced according to gender, driving experience and familiarity with the studied road, participated in this study.
As a consequence of this study, recommendations for road design improvement will be produced, being especially focused on the scope of RANKERS project, on the pursued objectives and its final results.

Keywords – driving behaviour, infrastructure, curvature, speed

References

Abstract

Single vehicle accidents (SVAs) in Europe represent 35.5% of fatalities in motorways and 27.3% in other roads [1]. This type of accidents implies a close relationship between the driver, the vehicle and the road infrastructure. The latter constitutes one of the key elements as there are not other vehicles involved. Therefore, road infrastructure can contribute to enhance safety levels. Nevertheless, the road infrastructure design and devices may have also influence in other types of crashes, making its influence in road safety even more relevant. On the other hand, road infrastructure is managed by road operators (either public or private) with limited economic resources to invest properly through actuations on road infrastructure. Moreover, during the last decades, safety issues have not been always deemed properly at all stages of a road cycle life (design, construction, pre – opening and maintenance) [2]. The earlier a safety problem is identified the lower cost is necessary to correct it. In conclusion, there is the need to address some important aspects: the relationship between the road infrastructure design and devices with traffic accidents, the effectiveness of some actuations upon road infrastructure avoiding accidents and/or decreasing their severity and the economic costs for their implementation in order to develop a cost–effective actuation for a safe road infrastructure.

RANKERS (Ranking for European Road Safety) is a European project, co–funded by the European Commission, aimed at developing comprehensive and practical recommendations for road infrastructure safety to enable optimal cost–effective decisions by road authorities and road operators. These recommendations cover dual carriageway roads and single carriageway roads in rural and urban situations. The relationship between the road infrastructure and the human factor is also tackled in the project in order to improve the driver perception of the road and to prevent the driver of being involved in conflict situations. The main outcomes of RANKERS are as follows: a comprehensive catalogue of scientifically – researched road infrastructure safety recommendations ranked according to their efficiency avoiding accidents and decreasing their consequences; a Road Safety Index aimed at identifying safety problems across road sections for each one of the road infrastructure issues (layout, signaling, hazards protection, roadside design, driver perception through road infrastructure, …).

With these complementary tools, road operators will be able to assess the safety of their road networks, identifying the specific problems that the road infrastructure may represent and then, they will be able to select the most cost–effective recommendations to be implemented on road infrastructure in order to enhance the road safety level.

Keywords – road infrastructure, cost–benefit analysis, road design, traffic safety, accident analysis
References

Evaluating the comprehensibility of visualized information displayed on Variable Message Signs as part of the EU Project IN-SAFETY

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Abstract
The IN-SAFETY Project is focusing on the pre-requisites for a successful implementation of Intelligent Transport Systems (ITS) in order to enhance the self-explanatory nature of roads. [1]

The European driver has to cope with more and more complex traffic environments, including vertical and horizontal signing; many of them are supported by telematics. In some cases, this may lead to an excessive workload imposed on the driver, for example:

- Striving to read the VMS (Variable Message Sign) message, while seeking the route in an unfamiliar environment (often in a foreign language and even with unfamiliar signs);
- Attempting to detect the required relevant piece of information among an abundance of information sources (e.g. in-car navigation system, Traffic Management and Information Centre or radio announcements, VMS signs, road signs, ADAS [advanced driver assistance systems] messages, etc.).

Comprehensibility of visualized information
In this context, the readability and understandability of variable message signs (VMS’s) are of at most importance as the number of VMS’ s in the European countries is growing fast. “During several decades now, much international and European R&D has been done, and actually is still continuing, on development and best use of Variable Message Signs, but there is no sound set of basic European recommendations for the benefit of the road authorities.” [3]

The objective of this research is to increase the self-explaining road environments by presenting a proposal of homogenized and comprehensive pictograms to substitute verbal messages on Variable Message Signs (VMS), thereby reducing the complexity of information and minimizing the use of local languages.

Within this research in sum four test series have been conducted. The various stages in the development and testing procedure for IN-SAFETY symbols follow the evaluation criteria and methods of ISO 9186 “Test methods for judged comprehensibility and for comprehension”. [4]

These methods are employed to verify the validity of re-designed and newly developed pictograms. Within the development of new pictograms the cognitive value of the pictograms is estimated both under regular and impaired visibility conditions.
1. Comprehensibility Judgement Test: The Comprehensibility Judgment Test was conducted to select the Best variant from a wide range of variants for further analysis. For 33 referents a total of 243 variants were tested by 825 participants. 56 variants were taken into consideration for more detailed testing or redesign. [5]

2. Static Comprehension Test: The first Comprehension Test was performed as a Paper and Pencil Test. In 2 countries, 84 variants of 33 referents had been tested and evaluated by 604 participants.

3. Animated Comprehension Test: The Comprehension Test on animated pictograms was conducted in 2 countries, performed as flash-based animation. 20 variants of 10 referents had been tested and evaluated by 300 participants.

4. Context Comprehension: The last survey evaluates the comprehension of animated pictograms, performed as flash-based animations of real-life-scenarios. 20 variants of 10 referents will be tested and evaluated by 300 participants in 2 countries.

To evaluate the influence of animated presentation in contrast to static pictograms the outcomes of the first two tests are going to be compared, also the influence of information overload will be addressed. The presentation will discuss as well the evaluation as the results of the test series, done in Austria, Hungary and Czech Republic.

Keywords – variable message sign, visualized information, evaluation methods, comprehensibility

References


Estimating subjective risk revealed through speed selection: 
the rational behavior perspective

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Abstract

Drivers want to drive fast and safely and they attempt to do it by choosing a certain speed when not impeded by other vehicles. This choice has been studied from psychological and statistical perspectives. The first perspective has introduced concepts of risk perception, rational behavior, risk homeostasis, or recently – workload homeostasis to interpret selection of speed by individual drivers observed in laboratory or in an instrumented vehicles [1]. This approach sometimes includes driver survey studies or measuring a driver physiological response (heart beat, skin galvanic resistance) in the attempt to conclude about the subjective/perceived risk. In the second perspective, ad-hoc statistical functions are fit to a sufficient number of speeds measured on various roads [2]. The second approach is focused on estimating the speed distribution parameters at individual sites rather than on individual drivers and it ignores the subjective risk component.

The research presented here tries to overcome the disadvantages of the two perspectives. We borrow the concept of rational behavior [3] and utilize the plausible speed-safety relationships [4] to propose a disutility function of driving. We assume that a driver minimizes this disutility by selecting speed $V_0$:

$$D(V_0) = \min_{\{V\}} \frac{c(y)}{V} + k \cdot V^n(x,y)$$

where: $c(y)/V$ is the subjective cost of the travel time along a unit distance dependent on driver and trip characteristics, $k n(x,y)$ is the subjective risk function, and $n(x,y)$ is the function of road, driver, weather and other variable. Solving the problem (1) yields the following average speed selection function:

$$V_0 = \left( \frac{c(y)}{k \cdot n(x,y)} \right)^{1/(n(x,y)+1)}.$$

The above function has been fitted to vehicle speeds measured along 67 suburban and rural four-lane roads in Indiana. The driver and trip data were not collected thus average speeds could be used instead of individual speeds. Weather conditions were the same during all the speed measurements. Driver population and average trip characteristics could be safely assumed same or similar at the studied sites. Consequently, the only characteristics considered in the model were road geometry and speed limit.
The fitted model (2) provided parameter estimates for the subjective risk function \( r = kV^{\alpha} \), the second term in model (1) with removed variables \( y \). The subjective risk function can be interpreted as a representation of combined average subjective risks of crash and of fine for speeding at a given average speed on the road. Although the total subjective risk on the studied road segments did not exhibit any obvious correlation with the crash rates on these roads, we have obtained one striking result. The crash rates were correlated with the subjective risk of crash (road geometry impacts with speed limit effect removed). The low values of the subjective risk of crash were associated with the high values of crash rates – the relationship postulated by some authors.

The paper discusses a possibility of using the proposed approach to estimate revealed risk perception of individual drivers in instrumented vehicles. The presented research direction may incite a new class of driver behavior models that would become essential components of future simulation models where both safety and mobility are jointly considered.

**Keywords** – behavior, rational choice, safety, speed, risk, perception

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**References**

Friday 9th November 2007
Time 11:30 am
Session C2
Driving simulation: road design

Chairman – Mr. Yasser Hassan
Chairman – Mr. J. J. Lu
Pre-crash investigation and interdisciplinary analyses using a dynamic driving simulator

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Abstract
This paper presents one experiment managed within the framework of the regional French project ST2 (French acronym for Sciences and Technologies for Safety in Transports). In this program, we study human reactions in order to try to adapt passive and/or active safety to driver behavior.

A first experiment realized two years ago highlighted the interest in using a driving simulator for the study of pre-crash driving situations [1].

A second experiment is underway in order to improve the methodological aspects and the realism of the pre-crash situation. From our interdisciplinary team the main improvement is the possibility to synchronize several types of recordings such as psychological, psychophysiological, neurophysiological, mechanical, automation, and biomechanical data.

The experiment is carried out with SHERPA, the car driving simulator of our laboratory. It is a dynamic-base simulator which is able to project images on three screens for a total front view of 180° and to send images on small LCD screens for the three rear views. The more difficult task was to synchronize the events of the scenario and all the recording data issues from several types of equipment.

Two driving sessions on the simulator are proposed to participants. During the first one, they have a short training in order to familiarize themselves with the simulator, and they also answer to a series of questions especially about their driving habits, and their previous car accident(s) if any.

The second session is performed at least a week after. Participants drive along a run of 50 kilometers. They begin with a road and take an entrance ramp to drive on a motorway. Then they take an exit ramp to go again on the road. They can speed up to overtake slow or braking vehicles if it is possible, or they can slow down to stay behind them.

Before the end of the experiment, stress situations occurred in order to make the driver attentive. The last traffic event is the pre-crash one. In this situation the driver can not avoid a traffic accident with a truck. Before it, the truck sounds one’s horn. At the time of the virtual impact a small bump is realized to simulate the movement of a little collision, and in order to be realist, a piece of foam is projected on the driving simulator’s windscreen.
At the end of the experiment, participants answer a series of questions about their subjective perception of the crash, and about the relevance of additional equipments that could improve safety. Moreover, we integrate physiological sensors, i.e. electromyography, electrocardiography, respiratory rate, electrodermal activity, and mechanical sensors on the seat, the steering wheel and pedals, in order to determine human characteristics along normal driving condition and during pre-crash and crash incidences.

All this pool of data aims at improving knowledge about drivers’ reactions just before the accident. In order to improve road safety, such information has to be considered in complement to data provided by real accidents and by crash tests with dummies.

*Keywords – pre crash simulation, multi-source data, human behaviour, data analysis, human modelling*

**References**

Implementation of road safety audit and inspection in the Czech Republic

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Abstract

Road Safety Audit (RSA) was introduced in the Czech Republic during the year 2006. It took nearly 10 years of effort. A few pilot audits (approximately 30, mainly regarding new roundabouts and connections of new supermarkets to the existing road network) were carried out during the last decade by the team of traffic engineers from Transport Research Centre (Centrum Dopravniho Vyzkumu – CDV, the governmental research institute). The Czech Republic also took part in project of the Fourth Framework Programme called SAFESTAR in 1998, where the Report on Road Safety Audit was prepared and first draft national methodology was written. Unfortunately, the implementation of RSA failed due to many, mainly decision-making barriers, in 2000.

The second attempt to implement RSA started in April 2004, when the Czech National Road Safety Strategy was approved by the government. RSA is mentioned as one of the suitable tools there to improve road safety. The RSA methodology was prepared by a team of traffic engineers from the Transport Research Centre and published in May 2006. The definition of RSA used in this methodology is based on PIARC findings and states that RSA is a systematic procedure, which incorporates modern traffic safety knowledge into the road planning and design process with the purpose of preventing traffic accidents [1]. The procedures of conducting RSA described in this methodology are based on the UK experience. RSA is suggested to be conduct in four stages, which represent the following typical road design planning steps:

- Feasibility Stage, Study
- Plans for land use decision
- Plans for construction decision
- Final plans

After publishing the methodology, the first comprehensive training courses aimed at training auditors were carried out by CDV and the first 58 auditors were accredited at the end of October.

It is necessary to note that even though RSA is mentioned in the Czech National Road Safety Strategy as the suitable tool for improving safety of traffic schemes, the whole process of RSA implementation has nevertheless been suffering from a lack of official support and can be described as a “bottom-up” process.

Conducting a RSA is voluntary. There are many barriers, especially on the political and decision-making level. Not only politicians, but also many transport professionals are not familiar with the whole philosophy of RSA. They are afraid of lengthening and unnecessarily enhancing the whole design process, arguing that
Czech technical standards are safe enough and no other safety checks are necessary. CDV tried to raise awareness of RSA by organising a set of 14 one-day courses (one in each region of the country) in 2006. All were well attended by transport professionals, road administrators, local authorities, traffic police and staff from maintenance agencies (in total, 550 professionals took part).

Despite the fact that RSA is not obligatory, there is increasing demand for conducting RSA between investors in these days. So maybe most of the barriers will be broken in the near future.

Regarding Road Safety Inspection (RSI), the process of its implementation has been started in the Czech Republic this year. The experiences learned in the process of RSA implementation can be very useful for the success in RSI implementation.

*Keywords – Road Safety Audit, Road Safety Inspection*

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**References**

Road users’ socio-economic status and road safety in Denmark

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Abstract

Road safety if often measured in terms of road accidents. A road accident results from the interaction between three main elements: the vehicle, the surroundings (road infrastructure, weather conditions, etc.) and the road user. The road user is by far the most important, complex and difficult element to deal with [1; 2]. Many road accidents are provoked by a mistake or risky behaviour of the road user. The main road safety goals when considering the human factor are to prevent human mistakes and risky behaviour from occurring in traffic (active safety) and limit or mitigate their consequences (passive safety).

This study considers the human factor in road accidents by analysing the socio-economic background of people involved in road accidents in Denmark. The goal is to investigate if there are specific socio-economic groups, who are at increased risk to be involved in road accidents, thus specific measures could be suggested to target these groups. Of special interest are individuals who were involved in more than one accident and people with criminal behaviour, since these two characteristics indicate propensity towards high accident liability [2; 3; 4]. To investigate the problem, all persons above 15 years of age living in Denmark in the period 1993-2003 were considered. The following information streaming from a number of national registers is used: age, gender, personal income, education, family status, ancestry, criminal records (if any), and involvement in road accidents. Only road accidents with personal injuries registered by the police are used. No personal data (such as name, address etc.) were available, i.e. the subjects are completely anonymous. The study population is grouped into classes according to age (four groups), gender (two groups), income (four levels), education (four groups), ancestry (three groups), and criminal behaviour (four groups). For each individual the number of involvement in road accidents during the study period was counted. Multivariate logistic regression is then used to evaluate the risk (in terms of odds ratio, O.R.) to be involved in road accidents for the different groups.

The study population consists of 5,072,871 individuals. From 1993 to 2003 about 156,277 of these individuals were involved in road accidents; 5993 (3.8%) had two and 446 (about 0.3%) had three or more road accidents. There was observed a tendency in decreasing of the average age with the increasing of the number of accident a person was involved in. Not surprisingly [3; 4; 5], young males (16-24 years) were found to have higher accident risk than other age and gender groups. The accident risk seems to decrease with increasing of the education level. The highest odds for being involved in road accident were found among individuals with a criminal record: O.R.=2.5 (95% CI 2.4-2.5) for persons who committed only non-traffic law violations and O.R.=8.2 (95% CI 8.1-8.3) for people with both traffic and other laws violations as compared to the non-criminal group.
The paper will discuss if a specific road safety interventions can be designed to target the high risk groups briefly described above.

**Keywords** – human factors, socio-economic groups, road accidents

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**References**

Simulation of road defects to incorporate safety measures in programming maintenance interventions

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Abstract

The damage of road pavement is one of the main causes of danger in transportation system, as confirmed by accident statistics. Actually maintenance and rehabilitation are too often influenced by limited economic funds, so that the traffic safety is often critical.

In literature there are different defects and damages manuals that show geometric characteristics and causes but no or few information about maintenance program.

Simulation of pavement damages characteristics and evolution as simulation of tyre-pavement contact are useful tools for developing consistent and safe rehabilitation programs.

Pavement defects make the pavement surface irregular, modify its functionality and driving comfort, and consequently the probability of accidents increases. These irregularities, if not appropriately contrasted, can evolve rapidly and in very different manners, causing different typologies of damages and even increasing the severity of accidents.

In the simulation of vehicle dynamics is crucial to define a “safety limit”, beyond the stability of the vehicle is not guarantee and the vehicle is out of the driver control.

If the pavement conditions respect this limit, the traffic safety accords to needed standards. The approach based on “safety limit” is useful to set priorities and effective rehabilitation programs.

The plurality of variables that must be considered and the mutual relationships away them make the simulation a strategic tool. This study presents the first results that have been obtained through the use of vehicle dynamics simulation, under different tyre-pavement contact conditions that could occur according to different damages. Many different cases have been simulated, considering different road geometries, vehicle speeds, contact conditions.

Vehicle trajectories and dynamics have been studied and unsafe conditions identified.

Finally the perspectives of this simulation for road safety are outlined and the next phases of the research are explained.

Keywords – maintenance programs, road defects, vehicle behaviour
References


3. Tighe S., Li N., Falls L., Hass R. - “Incorporating road safety into pavement management ”, *Transportation Research Record* 1699


Assessing the safety implications of differences in road geometry: application of case-control methods

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Abstract

One of the principal tasks of road safety management is the estimation of the safety effectiveness of differences in road geometry: e.g. is it safer to build a road with 12 foot lanes and 6 foot shoulders or 12 foot lanes and 7 foot shoulders? By how much is it safer?

This paper describes the use of case-control-based methods to estimate the safety effectiveness of geometric road elements. This is a new application of a method used frequently to assess risk for driver and vehicle groups, but rarely used in road safety studies. The major advantage of the case-control method lies in the ability to conduct comparisons across sites, while controlling for potentially confounding factors (such as average daily traffic and speed limit).

The paper includes a summary of the epidemiological basis for the use of the method in road safety studies. An application is presented using crash, roadway inventory, and traffic data for 5 years (1997 – 2001) from the state of Pennsylvania.

Specifically, there is an assessment of the safety effect of changes in lane and shoulder width for 2-lane rural roads.

The application includes a case-control approach with conditional logistic regression models. The model estimates yield odds ratios, which can be interpreted as the ratio of crash odds for a particular lane or shoulder width, compared to a baseline width. These are similar to crash (or accident) modification factors commonly used in the US. Ratios above 1.0 indicate increased risk, while those less than 1.0 indicate reduced crash risk.

The model estimates are compared to effectiveness estimates developed by an expert panel in the U.S. The model outputs are generally consistent with the estimates from the expert panel demonstrating that the method has potential for estimating safety effectiveness. The paper concludes with suggestions for future research.

Keywords – case-control methods, safety of geometric elements, crash modification factors, conditional logistic regression, safety of lane, shoulder widths
References


Signalized intersection level of service based on safety

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Abstract

The Highway Capacity Manual (HCM) presented the concept of “Level of Service” of a highway facility. In the original definition, level of service is a qualitative measure of the effect of a number of factors, which include speed and travel time, traffic interruptions, freedom to maneuver, safety, driving comfort and convenience, and operating costs [1]. That is to say, the service measure of level of service is a comprehensive measure, only thus it can objectively reflect various status of operation for a highway facility.

Intersections are important pivots in road network, and are also accident prone locations. In United States, 55 percent of all urban vehicle crashes occur at intersections, 32 percent of all rural vehicle crashes occur at intersections, 23 percent of urban fatal crashes occur at intersections, 16 percent of rural fatal crashes occur at intersections [2]. Other countries also have similar situation. But in current HCM, signalized intersection level of service does not include safety measure, so the level of service can not reflect intersection safety status. To address this problem, Ha and Berg used conflict opportunities to develop safety-based level-of-service criteria for isolated signalized intersections [3], but the safety-based criteria were not as sensitive to changes in prevailing traffic, roadway, and signal timing conditions as the traditional delay-based measure. At a conceptual level, Spring proposed a method to integrate safety into the HCM using fuzzy set theory [4]. In addition, Linn Zhang and Panos D. Prevedouros developed a methodology that quantifies potential conflicts between left-turning vehicles and opposing through vehicles and pedestrians, and combined delay with safety [5]. But the methodology was based on many assumptions.

This paper brought forward the concept of safety level of service for intersections. In order to convenient and effectively estimate the safety of signalized intersections, the authors were not based on crash data or traffic conflicts to evaluate safety, but on the factors that influence safety level of service, such as points of conflict, traffic signal, traffic signs, traffic marking, and so on.

According to those factors, the model of safety level of service for signalized intersections was built, and the intersection risk index was regarded as evaluation measure of safety level of service. In HCM 2000, the efficiency measure of signalized intersections is average control delay, it does not include explicit safety indicator. So the levels of service do not reflect the safety conditions.

The paper combined control delay and intersection risk index, and considered the delay and risk index (DR) as a new service measure of level of service for signalized intersection. According to distribution of DR value, new level of service for criteria for signalized intersection was updated A-F levels. The new level of service was applied to evaluate the operation of signalized intersections.
The results show that the new signalized intersection level of service can objectively reflect operation efficiency and traffic safety for signalized intersection.

Keywords – signalized intersections, level of service, safety level of service, traffic safety

References
Influence of credibility of speed limits and the use of an Intelligent Speed Assistant (ISA) on speeding behavior

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Abstract

This paper reports on a driving simulator study about the influence of credibility of speed limits and the use of an Informative Intelligent Speed Assistant (ISA) on speeding behavior. Speeding is a central issue in road safety. Improving credibility of speed limits and introducing Intelligent Speed Assistant (ISA) are considered as short term possibilities to reduce the percentage of speeding offences. A speed limit is considered as more credible when the limit is better in line with the intuitive expectation of the road user in that situation. The credibility of speed limits is determined by a broad range of road and road surrounding characteristics. The informative ISA is an in-car application that informs about the speed limit in force and warns in case of exceeding this limit.

A total of 41 subjects participated in the study. During the experiment the subjects drove along a set of rural roads with speed limits of 60, 80, and 100 km/hour.

The credibility of the speed limits was manipulated by varying a number of road characteristics, being road width, presence of vegetation, and the type of separator. These characteristics were identified in the literature as being relevant for speed choice. The credibility deviated from optimal in two directions: less credible because the speed limit is experienced as being too high for the road and its surroundings, or because it was experienced as being too low. During the experiment, half of the subjects were supported by an ISA system, and the other half were not.

The ISA system was integrated in a basic navigation system

Based on this driving simulator study new insights are obtained in the speed behavior with respect to more or less credible speed limits, in situations with and without the use of an ISA system. The credibility of the speed limits influenced driving speed. When the speed limit was more credible, the driving speed was closer to the limit; when the speed limit less credible (experienced as being too low), the subjects exceeded the limit. In general, ISA had a strong speed-reducing effect. This effect got stronger as the limit became less credible, and was especially so for situations where the limit was experienced as being too low.

The study also examined the effect on exceeding the limit and the effect on speed differences. The expectation was confirmed that drivers exceeded credible limits for shorter periods than limits they considered too low.

The effect on speed differences is more ambiguous, but there are indications that a credible limit results in smaller differences than limits that are experienced as too high or too low.
The general conclusion is that the direction of the credibility effect found conforms to the expectation. Given a particular road and surroundings, if a speed limit is experienced as being too low, the subjects are inclined to keep to it less than when they regard it as being credible.

Keywords – speeding behaviour, credibility of speed limits, Intelligent Speed Assistant (ISA), roadway design
New algorithm for accident rate prediction
based on hazard analysis concept

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Abstract
A new advanced and effective method is proposed and validated to assess the safety of road infrastructures, offering a very promising perspectives in the field of road safety design and management, towards the traditional road engineering models.

The method is based on the Hazard Analysis theory, with the purpose to assess the risk of accidents by an in-depth investigation of each manoeuvre.

Actually by the accident statistic it is possible to aggregate the events in four classes, most representative of the all road accidents. According to literature, each manoeuvre is described by one tree of events, the product of probabilities on the critical path gives the probability of the critical event assuming the statistical independency among the steps.

The equivalent risk of an accident is the sum of each probability of all the critical paths to a risky event, multiplied to the severity of the event.

The model has been calibrated from observed or simulated data. To make the calibration mostly effective and to make the method efficient an automatic algorithm has been developed.

This software evaluates the expected probability of accidents, including the role of human factor under multidisciplinary perspective by an iteration process calibrated using results and evidences from interactive driving simulations and observed data. This software is effective to assess different rehabilitations and safer options as a decision support system for road safety assessments.

The paper finally shows some promising applications.

Keywords – hazard analysis, accident prediction, driving simulation
Road safety indicators: 
Swiss results in Vaud Canton

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Abstract

With the rapid deployment of Intelligence Transportation Systems (ITS), real-time characterization and prediction of network state play a key role in various ITS applications, such as Advanced Traffic Management Systems (ATMS), Dynamic Vehicle Navigation Systems (DVNS) and Advanced Travel Information Systems (ATIS). This real-time characterization is quite well addressed from traffic perspective, with a variety of performance indicators, [1]. However, there is a huge need for real-time, reliable and effective indicators to assess traffic situation from a safety perspective. This is the main objective of FUSAIN project (fusion of safety indicators; FUSAIN project is sponsored by Swiss government funds).

FUSAIN aims at using existing safety indicators, developing new ones and fusing them in order to better capture, in real-time, the safety state of the traffic, also taking into account weather effects. This real-time information is essential to road operators for better regulation of the traffic, mitigation of the severity of accidents and reduction of their occurrence.

Using traffic detector data, it is possible to evaluate in real-time traffic safety indicators. Two main approaches can be found in the literature: One tries to correlate traffic measurements to accidents, [2; 3]. Another focuses only on traffic measurements and more intuitive rules of what is safe or unsafe, [4; 5].

The first approach can be very informative, regarding past accidents: Black spots can be identified, as well as recurrent traffic situations before accidents. So statistics enable to qualify accident risk in each traffic situation. Yet, accidents are usually rare enough to discard this statistical approach. All the more as traffic situation before the accident is not always known, especially when traffic detectors are not closely spaced on the network: There may be several kilometers between the location of the accident and the nearest traffic detector.

The second, more intuitive, approach does not rely on accidents. Indeed, the situation can be dangerous without ending in an accident. In fact, most risky situations end into crash avoidance. Risk between two consecutive vehicles can for instance be based on their time headway. The lower the time, the higher the risk. Relative speed can also be taken into account. Then, for platoons, risks can be cumulated, e.g. increasing the risk of a vehicle when the front vehicles have already too low time headways. But how to decide what is safe and what is not? How often can a safety indicator warn a road operator before it is considered as useless (too many false alarms)? And still reacting to most accidents (not too much misdetection)?
This paper studies existing safety indicators on 4 years of Swiss data for Vaud Canton motorways, which includes individual vehicle data of traffic detectors (speed, time headway, length, and vehicle category), accidents records and road weather data (type of precipitation, air temperature, road temperature, quantity of water on the road).

As there were too few accidents close enough to a traffic detector, the first approach was not do-able. Yet, the second approach has been tested. Different microscopic safety indicators are compared on several motorway sections in terms of how often they give a warning and if they give it for a same traffic configuration. Weather conditions have been taken into account (especially rain or snow on the road, which can have an effect on some safety indicators, for instance those using stopping distance).

Finally, tests are conducted to check if some safety indicators better reacted before an accident than others. For this test, accidents have been filtered to discard special situations such as drunk-driving.

**Keywords – traffic safety, safety indicators, real-time, traffic individual data, accident data**

**References**

Safety evaluation algorithm for signalized intersections in Abu Dhabi (UAE) using artificial intelligence

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Abstract

Vehicles traveling through signalized intersections in Abu Dhabi experience high accident occurrence. An investigation was carried out to improve highway safety in Abu Dhabi (UAE) [1]. This paper provides a detailed signalized intersection safety evaluation algorithm utilizing expert opinions and employing artificial intelligence techniques (AI).

Using crash data, the algorithm is calibrated and the correlation between the resulting Intersection Safety Index (ISI) and crash rates in some selected signalized intersections is performed. The developed algorithm and technique can be extended and applied in other regions and cities of similar environment and driving conditions.

The developed ISI is similar to other indices developed for highway sections [2], pavement condition, and/or bridge safety condition [3]. It considers only the physical characteristics of signalized intersections. This approach is based on an implicit assumption that the non-random portion of driver error is largely affected by and correlated to the intersection’s physical features. Therefore, the availability of such a tool for estimating safety index at signalized intersections utilizing their main characteristics will help highway officials to design and implement plans for safety improvements.

To develop intersection safety index, two forms have been designed to collect experts’ opinions. The two forms contain 25 variables thought to affect intersection safety. The variables have been classified into five major groups; namely: pavement condition, geometric design characteristics, traffic signal characteristics, traffic control devices conditions, and traffic characteristics.

In the first form each variable has been assigned four different rating levels. The first form was used to gather expert opinions regarding the relative importance of each variable in each group. In the second form, the experts were asked to select the most important 15 variables out of the suggested 25 variables. The experts were also asked to rank the selected 15 variables and suggest the weight by which each variable would affect signalized intersection safety. In total, 100 experts were asked to fill these forms, where these experts were equally distributed between government engineers, highway consultants, highway contractors, university professors, and researchers all over UAE. The selected experts were all highway or traffic engineers with a minimum five years of experience in highway planning, design, construction, management, or research.
It was found that the most significant factors and variables governing the traffic safety at urban signalized intersections in the City of Abu Dhabi were: the type of intersection, allowed yellow time, percentage of heavy vehicles, traffic signal sequence, and surface rutting. Clearly, these five variables cover geometric design aspects of the intersection, operational characteristics, and surface conditions of the intersections. One can expect that understanding how these variables could affect safety would assist the traffic and highway engineers to make proper decisions to improve the safety and reduce the risk of accidents at the intersections.

Finally, the developed ISI was calibrated with actual crash rates at 48 selected signalized intersections and strong correlation has been computed.

Keywords – safety evaluation, signalized intersection, expert opinion, artificial intelligence, safety index

References

Prediction of vehicle loss of control
during emergency maneuvers

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Abstract
This paper describes a pattern recognition approach to determining impending vehicle loss of control during emergency maneuvers. Hidden Markov Models (HMMs) [1] are used as a recognition tool to anticipate loss of control based on steering, yaw, and yaw rate data.

This work was motivated by the need to automatically assess vehicle loss of control while studying the effectiveness of Electronic Stability Control systems in emergency traffic situations [2; 3]. Whereas algorithmic approaches can be calibrated to provide recognition based on numerical thresholds, such techniques do not always apply uniformly on all possible pavement conditions or different vehicles. When using pattern recognition techniques, existing data is used to train a model which can then be used to recognize similar situations automatically, and without an explicit dependency on numerical thresholds or other specific values.

This approach has been shown to work satisfactorily when applied to recognition of routine maneuvers in an actual vehicle [4] as well as in simulators [5].

In this paper we extend this approach to a more challenging situation of detecting loss of control during severe maneuvering.

The paper presents this approach, along with experimental results of applying this technique maneuvers obtained on simulator experiments involving emergency maneuvers that often led to vehicle loss of control.

Keywords – electronic stability control, HMM, loss of control

References

Abstract
According to literature, the analysis of traffic conditions and operating speeds are of main importance for road engineers. The traditional approach is based on observations and surveys on the road. Under this empirical view, traffic is studied in a specific road section according to the Eulerian analysis. Dynamic measurements of vehicles while driving are very difficult to be performed.

On the basis of their experience in interactive driving simulation in virtual reality environment, the authors evaluate the possibility of studying, through simulation, the traffic unsteady flow under a Lagrangian approach. This new perspective becomes possible to be investigated because the simulation technologies are naturally more suitable for analyzing the variability of traffic, speeds, trajectories and dynamic conditions of vehicles along all the route.

This paper shows the results of a large number of experiments intended to verify the feasibility and the significance of this new methodology for experimental analysis. The experiments have been carried out considering different traffic flows; for each condition, the kinematic and dynamic parameters, the position and lateral displacement of the vehicles and other parameters of a significant numbers of drivers have been processed.

The conclusion of the study confirms the reliability of the method, moreover the simulation technology makes it possible to develop, under repeatable conditions, so many experiments that the statistical significance increases greatly rather than the traditional approach based on the real truth observations.

Keywords – traffic flow, vehicular interferences, virtual reality simulation, Lagrangian/Eulerian approach
New technologies to improve road safety

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Abstract

The constant increase of the traffic flows and the impossibility to correspond this increase with the current infrastructures makes necessary the use of new technologies to improve the traffic flows and to guarantee road safety. New technologies have made possible the creation of more advanced systems and knowledge models to traffic control and management: the Intelligent Traffic Systems (ITS). [1]

ITS can be grouped basically in three big sets [2]:

a) road monitoring;

b) traffic management;

c) information systems.

Monitoring systems are in charge of the road data capture information. Traffic management systems support road managers in road management tasks.

Information systems are developed to exchange traffic information. It includes on-trip information (VMS, RDS-TMC, SMS alerts, WAP, etc) and pre-trip information (Internet, information points, teletext, etc). The joint use of these systems allows road managers to develop different services such as preventive incident systems.

Dirección General de Tráfico (DGT), the Spanish organization responsible of traffic management, is working hardly to incorporate new technologies to develop new ITS systems to provide new services. The purpose of this paper is to present the Spanish ITS systems and services to improve traffic flows and road safety and the impact of them in accidentally. The services presented are focused in:

• Incidents management: These services could be grouped in two wide areas: preventive where the systems are dedicated to anticipate situations that are dangerous and Incident detection and management in which the systems are in charge of detecting incidents once they have occurred and of managing the consequences that incidents produces on the road network.

• Traffic Information Services: Developing and installing travel time systems, studies and experimentation of a new type of VMS, in-vehicle information and navigation systems (RDS, TMC, S-DSD, T-DAB), internet services and information exchange (DATEX).
Keywords – intelligent transport systems, road safety, incident management

References

Friday 9th November 2007
Time 11:30 am
Session G2
Infrastructure engineering, human behaviour and vehicle technology

Chairman – Mr. Andrew Tarko
The role of road infrastructure on accident rate

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Abstract

Although the main contributor to road accidents is driver error, elements of the road infrastructure such as lane width, surface condition, horizontal alignment, etc. can also increase the risk of accidents.

The European Commission sponsored project “RANKERS” has investigated the role of road infrastructure on traffic to develop monitoring and countermeasure selection protocols to assist in road construction and maintenance. Two of the RANKERS consortium partners have conducted a detailed investigation of the relationships between road infrastructure and accident rate.

These analyses have required the matching of accident location with infrastructure characteristics.

National accident data spanning 6 years have been collated with physical properties contained in road inventory databases as well as maintenance databases collected as part of regular pavement maintenance programs (Pavement Management System – PMS). Accident data was matched to road locations with a 200 m accuracy and then sorted into bins where accident dates among infrastructure characteristics could be compared.

Results of these analyses of accident rate and road configuration have been useful to confirm previous findings in the literature as well as contribute additional information. As expected, accident rates increased with decreasing curve radii and also decreased with increasing posted speed limit. Of particular interest were the findings in one country where the risk of accidents in curves was higher for right hand curves than in left hand curves, even when superelevation would support vehicle cornering capabilities. In these conditions it was also noted that the type of accident changed as overtaking accidents increased in right hand curves.

Data collected in these studies have been used to develop criteria to identify critical road sections and suggest types of countermeasures suitable for the accident types involved. Interaction with Human Factors research is necessary to further understand the links between accident causation and road infrastructure elements.

Keywords – Road Infrastructure, Accident Data, PMS, Safety, Accident Rate
Simulated road environment and safe driving performance analysis

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Abstract

This work presents results of the study conducted in co-operation of British and Polish researchers in frame of the BPRPP, British-Polish Research Partnership Programme. The project aim is to test the safety effects of applying the Self Explaining Road SER concept to road design. The work shows the potential capabilities of the designed road view simulation and visualisation techniques into traffic safety improvements process.

Theoretical studies of the current knowledge on Self Explaining Road (SER) concept and its implementation into road design research and design practices, as well as analysis of questionnaire research conducted in Poland, let authors to design a study on perceptual evaluation of the SER signs in perspective projection, from drivers point of view.

The first steps were the graphical modelling of virtual road and road environment and the designing of graphic information system (horizontal road signs of road geometry) in line with the SER concept. Also architectural objects perceptual properties were tested, based on graphical modelling of objects observed by drivers along the road.

This interdisciplinary experimental design required experts from traffic psychology, road design, architecture and computer graphics.

Pilot study results obtained in a simple simulation environment in Poland let authors to select the data base for the main experiment to be conducted in driving simulator.

The two main experiments were made, one in Britain (ITS) in the fully simulated environment of the Leeds driving simulator, the second in a simple computer laboratory in Poland (CUT).

During the experiments, the safety effects of applying the Self Explaining Roads (SER) concept to road design were tested. The evaluation tests the driver performance in simulated road environments, comparing SER with non-SER road scenes.

The evaluation is dual: a subjective assessment of the visual road environment and also objective evaluation of driving performance in the fully animated environment in a high fidelity driving simulator.

Keywords – SER concept, simulated road environment, speed perception, safety
References


An analysis of driving performance evolution under high workload conditions

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Abstract
The experiment described in this paper tries to reach high driver workload levels by imposing the speed value. These high workload levels are expected to magnify the variations of the driving performance indicators with respect to “normal” conditions. The speed performance was imposed by means of a car following task. The leading car had two possible speeds (90 and 110 km/h) and cruised into two traffic conditions (low and high). These conditions defined four different scenarios. In addition to the driving task, the driver was asked to perform secondary tasks which consisted in mathematical additions and also in Working Memory Span Tests.

The choice of these tasks was done after a literature review, in order to appeal to different mental resources of the driver: the mathematical operations imply a cognitive processing, whereas the Working Memory Span Test implies memorization efforts.

These tasks were carried out using either a cell phone or a LCD screen coupled with a radio control unit. Whatever the “modality” used (auditory or visual), the questions were presented to the subject in the same way: question, list of possible answers, and finally request of an answer according to the modality (verbal or keyboard input).

The experiment was realized with the SHERPA driving simulator of the laboratory, a copy of the simulator developed by PSA Peugeot Citroën. It is based on a Peugeot 206 mockup fixed on a six degrees of freedom motion platform. The front field of view equals 180° whereas the rear field of view is about 45°. The journey was a 16km rural road, which was followed four times (the four journeys were differentiated by the curves orientation and the environment). During a trial, the subject was asked to evaluate his workload after each secondary task and also after each phase without secondary task. These evaluations were done by means of the Instantaneous Self Assessment Method (ISA) materialized in the car by a 7 keys keyboard integrated in the dashboard. This measurement was completed by a NASA-Task Load Index filled after each run. Many other parameters were recorded thanks to the simulator, dealing with the actions of the driver on the car, the subject vehicle dynamic and the traffic kinematics. 16 drivers took part to the experiment which lasted about two hours and a half.

The data analysis focuses on both quantitative and qualitative variables. As expected, the measurements collected during the driving via both the ISA and the TLX scales shown that the secondary tasks increase the workload felt by the subject.

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The results also shown that the effect of the traffic on the workload is prevalent with respect to the effect of the speed of the leading car. The analysis of the objectives data were conducted according to the following approach: a selection of the different variables recorded during the simulation was made, re-sampled and then characterized according to indicators usually used in the literature.

A first principal component analysis made it possible to make a selection of the different variables according to their correlations and their informative contents. This first selection was next refined using multiple correspondences analysis.

In the paper, the results of these different analyses are discussed.

The next step of this word is to build a real-time workload indicator from the indicators selected through the data analysis.

Keywords – car driving simulation, driving task demands, mental workload, self assessment, data analysis

References
Estimating road accidents of Turkey based on regression analysis and artificial neural network approach

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Abstract
Traffic accidents causing deaths and injuries are serious traffic safety problems of all countries. Each year, approximately 1.2 million people die in traffic accidents and as many as 50 million people are injured worldwide. Similarly, Turkey is seriously affected by traffic accidents and their results. Every year, all over the country approximately 5000 people die and more than 135,000 people get injured in the traffic accidents.

This study proposes two new analytical models and an Artificial Neural Network (ANN) model to estimate the number of accidents, fatalities and injuries in Turkey utilizing historical data between 1986 and 2005. The data between the years of 1986-2000 were used to develop the models and the rest of a five-year data were utilized for testing the developed models.

The first of the analytical models is a modified form of the Smeed accident prediction model [1]. The second one is an adapted form of the Andreassen model to Turkey [2]. In the model development, the number of vehicles, fatalities, injuries, accidents, and population were taken as model parameters. In the ANN model, the sigmoid and pureline functions were used as activation functions with feed forward-back proportion algorithm [3, 4].

The model results were compared against the observations and it was found that the ANN model performed better than the other two analytical models. In order to investigate the performance of the models for future estimations, a fifteen year period from 2006 to 2020 was employed. Considering the fact that Turkey is likely to enter the European Union by 2020, road safety strategies were evaluated with two possible scenarios. In the first scenario, the annual average growth rates of the population and the number of vehicles are assumed to be 1.7% and 7.5% (average growth rates between 1986 and 2005) respectively. In the second scenario, the average number of vehicles per capita is assumed to reach 0.45 which represents a three-fold increase in fifteen years.

The results obtained from both scenarios reveal the suitability of the current methods for the road safety applications.

Keywords – accident prediction models, artificial neural networks, Turkey, injuries
References


Advanced visualization of road environments by means of programmable graphics hardware

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Abstract

Vision is a major part of human perception. In order to get results of a driving simulation experiment that are transferable to reality, it is necessary that the perceived simulated road environment matches reality as far as possible. Because vision is a major part of human perception visuals must be a major part of driving simulation.

This paper presents approaches done in the centre of driving simulation at BMW Group Research and Technology to improve the visualization of road sceneries exploiting the capabilities of state of the art programmable graphics hardware. For a long period of time graphics hardware had a fixed functionality and therefore limited the possibilities of realizable visual phenomena in driving simulation software.

The introduction of programmable graphics hardware to the market broke many of those existing limitations and provides software developers with a powerful functionality to affect real-time graphics processing. So called shader programs can be used to intervene the fixed graphics processing functionality and allow to implement customized visual effects. It is time to make this technology applicable for driving simulation now.

Methods for programmable graphics hardware are presented to bring the visualization of road sceneries to a more realistic level. Several techniques were combined and rearranged to come closer to the goal of creating a realistic representation of road sceneries. These methods are successively presented to build up a final technique layer-wise. In order to utilize the presented techniques real-time performance issues were regarded to keep the program applicable. At first an atmospheric lighting model for outdoor scenes [1] is introduced as well as a brightness correction to simulate the light responsiveness of the human eye [2]. Then the roughness of asphalt is visualized under different lighting conditions [3]. Subsequently the technique is enhanced to create the appearance of a non-uniform reflecting road surface. Worn out areas of asphalt reflect more specular light than rough less to traffic exposed areas. The varying reflectivity of asphalt is particularly observable when driving towards the sun. The next step is to visualize the small height variances of a road without modifying the underlying geometry. Therefore parallax mapping [4] is applied. This method is especially useful to display surfaces with an uneven structure like cobblestones or roads with a gravelly condition. To add details like little cracks or asphalt patches the technique is finalized by distributing random details in the virtual environment [5]. With this algorithm the pattern-like, synthetic look can be reduced that appears in most cases when a wide-stretched geometry is textured with seamless texture maps repeatedly.
The presented techniques to improve the visual quality of road sceneries increase the realism of driving simulation drastically. Landscapes are lit naturally, asphalt surfaces are visualized realistically and sceneries can be enriched with details. Using the explained methods leads the visualization of road sceneries of driving simulation closer to the goal of a lifelike simulation of vision.

Keywords – driving simulation, vision, road environment, 3D computer graphics, GPU rendering

References

A decision tool for improving road safety: from e-book to solution

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Abstract

RANKERS (RANKing for European Road Safety) is a research project co-funded by the European Commission in the Sixth Framework Programme designed to gain new knowledge by performing research and empirical studies of the road’s interaction with the road user and his vehicle in order to identify optimal road recommendations and predict their impact on safety.

In this context, RANKERS pursues the objective of developing scientifically-researched guidelines enabling optimal decision-making by road authorities in their efforts to promote safer roads and eradicate dangerous road sections.

RANKERS proposes to address traditional passive safety measures (“forgiving roads”) together with a better understanding of the accident causation scenarios, leading to a significant mitigation of the risk. And also wants to improve existing road safety inspection procedures by preventively evaluating the hazard potential of each road section based on a comprehensive panel of indicators (traffic data, maintenance data, road surface properties…).

The aim of Work Package 3 (WP) “Expert Assistance for Safety Review of Rural and Urban Roads“ is to provide a so-called “eBook”, where well known recommendations (state of the art) are presented to the users on electronic media. Together with user groups (road administrations, safety commissions, police forces) in at least three countries real case studies have been performed.

The University of Brescia, as partner of the WP3, is developing the e-book for the case of pedestrian and cyclist accidents.

The paper aims to present the structure of the e-book in the case of pedestrian and cycling accidents scenarios, showing the decision tree that leads users to one or several solution proposals for a given safety problem.

Furthermore, some specific cases will be presented, in order to describe how, the use of accident data can lead to countermeasures to improve safety for non-motorized users and to discuss some specific measures.

Keywords – pedestrian cyclist, road safety, accident scenario, non motorized mobility
References

5. Megherbi, B. (1994). L’insécurité d’une ville moyenne approchée par l’analyse fine des accidents et leur agrégation en scenarios types. INRETS, ENPC, Université Paris XII.
Friday 9th November 2007
Time 3:00 pm
Session D
Driving simulation: evaluation of operating speeds

Chairman – Mr. Alfredo Garcia Garcia
How driver risk perception affects operating speeds

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Abstract

Excessive speed is one of the primary safety hazards facing highway users. However, in many cases operating speeds exceed design speeds, and postings of speed limits are generally ignored by drivers. A recent response is to design selected roadways in a manner that will encourage drivers to operate at desirable speeds. This reflects a roadway design philosophy that relies on the roadway’s intrinsic design elements to encourage driving at the intended operating speeds with a minimal requirement for street furniture and signage to encourage compliance with these speeds.

The main objective of this research was to identify roadway elements and roadside features that could influence driver operating speeds in rural two-lane roads. Virtual Reality video simulations were employed and drivers recorded the influence of these elements on their judgments about the appropriate driving speed. This study evaluated the use of various means that could impact operating speeds and affect the driver behavior without compromising safety.

The driver/participants viewed the models by means of a projection on a large screen in a darkened room, simulating the windshield of a vehicle. A total of 35 models were viewed and models were presented randomly to discourage potential comparisons between models. Participants were asked to score their level of discomfort for driving on the roadway on a 1-10 integer scale. The viewing sessions were set in a manner where they could simultaneously accommodate significant numbers of subjects and gather their feedback through electronic audience response systems.

The response feedback is modeled through use of a fuzzy set system that allows designers to inspect the interrelationships of many different design parameters. Such modeling systems are particularly well suited to non-linear, data-sparse applications such as this. The arithmetic mean score for discomfort for each scenario ranged from 4.3 to 8.1, representing variation on the “discomfort” evaluation scale. Bearing in mind that these highway designs were presented at the same virtual speed, this represents a large difference in perceived driver comfort. The standard deviation results show that some scenarios generated stronger perceptual agreement than others.

Our results show that the approach of simulating the driving environment using visualization was effective in generating feedback.
This approach could allow researchers to avoid the expensive and time-consuming process of individually ‘processing’ subjects through a driving simulator simply to acquire sufficient data to have confidence in the overall results. Besides being scalable, the keypad method of data gathering also allows partitioning of the feedback by any number of desired demographic variables, while maintaining the efficiency inherent in simultaneous data gathering. Further, because all subjects experience the simulation simultaneously, variability in presentation method across subjects is minimized.

The second aim was to investigate which design elements, among the six considered, exerted the most influence and under which conditions. Because the input data comes from public forums the knowledge base “captures” public response directly.

Keywords – operating speeds, driver behavior, roadside elements, cross section design
Research on alignment design method of freeway in the mountainous area based on operating speed prediction

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Abstract

The number of traffic accidents has been decreasing gradually in the recent 5 years. However, the road traffic safety actuality especially in mountainous areas is still serious. This may be due to many factors including the limitation in road aspect.

Based on extensive literature reviews [1; 2] and analysis of the cause of the traffic accidents on highways in mountainous areas in China [3], some problems existing in the method of highway alignment design based on design speed were found. The actual design methods based on design speed only prescribe the minimum alignment design indices, so it can’t ensure the consistency between the alignment design indices and driving speed.

The practice has proved that the alignment indices decided by “operating speed” can better satisfy the demand of drivers’ safety driving. Existing operating speed models for alignment design consistency in China are mainly based on two-dimensional (2D) analysis of highway horizontal alignments. Combined with the practical situation, the operating speed prediction models and the method of road alignment design were studied in the paper.

Through the investigation and actual vehicle experiments on different kinds of roads in mountainous area, the free-flow operating speed data of different vehicles on freeways were collected by using radar guns, GPS and video counters. In order to establish the speed models, the road sections were divided considering the nature of the road environment and a new integrated alignment index was put forward.

By analyzing the great amount of field data, the relationships among the alignment design factors, speed, drivers’ psychology and physiology and traffic safety were discussed, and then the operating speed predicting models based on three-dimensional (3D) nature of highways reflected by the integrated alignment index were established. In the new model with three-dimensional alignment indices, the integrated influence of the continuous alignment and the approach speed on operating speed on alignment unit were considered. The validities of the models were also proved by the application. Then the operating speed model combined with the established spacial sight-distance, conflict analysis, car dynamics simulation safety evaluating models [4] were used to evaluate the freeway alignment design safety from multi-aspects.

Finally the method of the freeway alignment design based on the operating speed prediction was studied. The application showed that the new models consider more influencing factors and are exacter than the 2D models; the new alignment design method can ensure the highway operation safety effectively through the
design of sequential, consistent alignment and provide technical support for the research of freeway alignment design system in China.

Keywords – alignment design, operating speed, operation safety, safety evaluating models

References

Updating French formulas for operating speeds on horizontal curves

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Abstract
The knowledge of operating speeds is a major interest in highway design, highway signing, or highway safety studies. The so-called \( V_{85} \) (85\textsuperscript{th} percentile of the speed distribution of unimpeded passenger cars) is used for this in a lot of countries. In France, a set of formulas expressing \( V_{85} \) as a function of some geometric characteristics (width, radius of curvature, slope) have been established by the SETRA twenty years ago [1;2], and are widely used in guidelines or in computer programs.

A recent study has been undertaken for updating the formulas for curves (updating the formulas for ramps is still to be considered). After an extensive literature survey and a preliminary study on 6 curves, speed and geometry measurements have been performed on nearly 50 horizontal curves with various layouts on two-way two-lane highways on flat terrain, and a statistical analysis of the data has been realised, leading to a proposal.

The speed measurements have been done at two points of each curve, in the middle and about 250 m upstream, with devices non interfering with behaviours, and delivering speed, time of passage and category of vehicle. The geometric parameters have been obtained with a dedicated recording vehicle.

Statistical tests led us to retain as a criteria for defining passenger cars considered to be unimpeded, a headway greater than a threshold of 4 s.

As a part of the preliminary study, data have been matched so as to obtain for each vehicle the couple of its speeds at both points. It then appeared that the 85th percentile of the distribution of individual speed reductions between upstream and the middle of the curve (\( \Delta V_{85} \)) was in average about 40 \% higher than the difference of the two operating speeds at the same points \( \Delta (V_{85}) \). So, when this last one is used as an indicator of highway geometry consistency, as it is often the case, such a result should remain in mind.

During the speed measurement campaign, a problem occurred due to the fact that these measurements have been performed while a great number of speed cameras have been installed. This deployment had for effect to cause an important decrease of the speeds over the french road network, this appearing also in our sample. So, it has been necessary to make the data homogeneous, whenever the date they had been collected.
The statistical analysis showed that only two geometric variables had a significant effect on the operating speeds V85: the radius of the curve (or indifferently the curvature change rate CCR) and, in a much lesser extend, the sinuosity of the approach. Other parameters did not appear to modify the speed, maybe due to their correlation with another variable (e.g. the superelevation, highly correlated with the radius) or to a too small variation within our sample (e.g. the width of the road, mainly around 7 m). Apart from these geometric parameters, the presence of a speed limit sign also appeared to be significant.

The introduction of the approach speed as an explanatory variable did not appear to be satisfactory.

Various formulas for V85 have been established. When looking at their shape, it appeared that the best of them, of a statistical point of view, were very close to the initial SETRA-86 curve. So it has been decided to keep this last one, with only the introduction of a speed limit sign effect, for there was not any strong evidence to change for a new one. In the lack of new information for other widths than around 7 m, it has been also decided to keep also unchanged the initial formulas for 5 m and 2x2 lanes.

In fact, these formulas were certainly no more valid in 2002, but since that date, the deployment of automatic speed enforcement has lowered the operating speeds to a level which is, at least on our sample of curves, not far from what it was twenty years ago. However, this does not mean that driver behaviours have not evolved.

The paper is concluded by some remarks on the topic.

Keywords – operating speed, speed differential, horizontal curve, two-lane, rural highway

References
2. Gambard J.M. and G. Louah, “Free speed as a function of road geometrical characteristics”, in proceedings of the 14th PTRC summer annual meeting, Brighton, UK, 1986, pp. 139-149
Context-sensitive methods to influence operating speeds: case study of rural highway using casewise visual evaluation

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Abstract
Operating speeds exceed design speeds for many reasons. Moreover, excessive speed is one of the primary safety hazards facing highway users [1]. A recent innovation in highway design philosophy is reliance on the roadway’s intrinsic design elements to encourage driving at the intended operating speeds with a minimal requirement for street furniture and signage to encourage compliance [2].

The main objective of this research was to identify and quantify the perceptual influence of a range of combinations of roadway elements and roadside features that influence driver operating speeds in rural two-lane roads using real-time operator data. Another aim was to quantify multivariate nonlinear interactions of such design elements on the drivers’ perceptions of appropriate operating speeds [3]. A total of six design parameters were examined: roadway width (lane and shoulder), vertical grade, horizontal curvature, roadside barrier, plant intensity, and clear zone. The total universe possible with these six parameters numbers over 7000. A sample of 35 Virtual Reality video simulations was engineered and driver/participants viewed the models by means of a projection on a large screen in a darkened room, simulating the windshield of a vehicle. The models were presented randomly to discourage potential comparisons. Drivers recorded the influence of these elements on their judgments about the appropriate driving speed by scoring their level of discomfort for driving on each roadway on a 1-10 integer scale. The response scale was intended to correspond with suitability of the driving speed for the highway design being shown.

The experimental arithmetic mean score for discomfort ranged from 4.3 to 8.1. Since these highway designs were presented at the same virtual speed, this represents a large difference in perceived driver comfort. The standard deviations show stronger perceptual agreement for certain scenarios. The research team prioritized the most influential design parameters as horizontal and vertical curvature; roadway width; clear zone; and plant type. These five parameters yielded a total of over 450 possible design combinations. The stimulus/response feedback was modeled through use of a fuzzy set system, Casewise Visual Evaluation [4], that allows designers to inspect the complex, nonlinear interrelationships of many different design parameters. Such modeling systems are particularly well suited to non-linear, data-sparse applications such as this.

The results show that the proposed approach is feasible in modeling a drivers’ perceptions of risk. Simulating the driving environment using visualization was effective in generating anonymous, simultaneous, real-time feedback.
This approach allows researchers to avoid the expensive and time-consuming process of individually 'processing' subjects through a driving simulator simply to acquire sufficient data to have confidence in the overall results. The facilitated group/keypad method is scalable and allows demographic data segmentation, while maintaining the efficiency inherent in simultaneous data gathering. The second aim was to investigate which design elements, among the seven considered, exerted the most influence and under which conditions. Because the input data comes from public forums the knowledge base "captures" public response directly. This means that our method is likely to reflect current, cohort-specific public preferences more accurately than data taken from design manuals or other literature [5].

Keywords – operator speed, virtual reality, highway design elements, simultaneous multi-user evaluation, fuzzy set nonlinear model

References

Abstract

The consistency of a road alignment refers to the conformance of its geometry to driver expectancy. An horizontal curve that requires an excessive speed reduction in respect of the approaching speed to be travelled safely violates driver expectancy and, consequently, can be correlated with an increase in accident occurrence.

Therefore, the evaluation of changes in operating speeds along the alignment is effective to check the consistency of the road because it can identify the sequences of geometric elements that require an excessive speed reduction [1; 2]. However, to use the operating speed-profile as a consistency tool it is necessary to accurately predict the speed as a function of the road geometry. Unfortunately, the existing operating speed models are, in most cases, substantially different from one model to the other [3]. Therefore, an operating speed-profile model was developed specifically for the Italian two-lane rural roads.

The research pointed to these roads because their horizontal alignment can vary significantly, including sharp curves but also long tangents. In fact, the construction of these roads often goes back a long way and their alignments were designed without considering the speed of modern-day vehicles.

The availability of the operating speed-profile model will be an important tool for the safety analysis of the existing two-lane rural roads that will help to identify the necessary improvements. Moreover, it will make it possible to immediately verify new alignments during the design process. The operating speed-profile will be useful also in verifying the required sight distances (stopping and passing sight distances, preview sight distance, intersection sight distance, etc..) because it makes it possible to evaluate the necessary sight distance at each point of the road.

The speed database used in this research included 180 sites (tangents and circular curves) of 26 two-lane rural roads. The statistical analysis investigated the relationship between the speeds collected and the geometric characteristics of the roads. Each prediction model developed can be used to predict a different aspect of driver speed behaviour.

The first model predicts the speed reached on tangents of a road section that has a reasonably homogeneous alignment in geometric characteristics.

The second model predicts the operating speed on curves using the geometric characteristics of the curve and of the road section to which the curve belongs. These models are extensive revisions of the initial versions [4] and have been developed in light of the further data collected to complete the study.
The third and fourth models predict the deceleration and the acceleration rates adopted by drivers entering and exiting the curve [5].

These four prediction models were finally incorporated into the operating speed-profile model. This model can be used to generate a speed-profile along an alignment in accordance with the road geometry and to evaluate the consistency of new and existing roads.

In conclusion, the operating speed-profile model developed is a useful tool that can be effectively used in the safety analysis of the new and existing Italian two-lane rural roads.

**Keywords** – operating speed, speed-profile, acceleration rate, deceleration rate, two-lane rural roads

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**References**

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Poster Session
Development and implementation of a Road Safety Management System

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Abstract

Among EU countries, Portugal is the one with the highest rate of fatalities and injuries per 1000 inhabitants as result of road accidents. The most part (approximately 60%) of the accidents involving personal injury take place inside urban areas. The main reason for that fact is the chaotic road environment, namely the completely mixed up involving vulnerable road users and vehicles. This leads to the conclusion that a better understandable road network is needed for all users [1; 2].

As a result of the increasing public awareness and concern of the high social and economic costs of traffic accidents, the improvements to road safety have become a high priority for the traffic departments’ authorities of the countries and municipalities. Nevertheless, the budgets available are limited, which makes the problem even more difficult to solve. It is therefore important to ensure that the funding available for road safety improvements is efficiently invested [3]. One first and major step in this process is the identification of the most problematic black sections in the road network. The next step is the development of a Decision-Aid Tool that should provide suggestions for maintenance priority setting according to accident characteristics and proposals of likely countermeasures to specific safety hazards. The Decision-Aid Tool effectiveness in providing appropriate solutions can be evaluated through before-and-after analysis and the results are feedback to improve the system [4; 5].

This paper presents a Road Safety Management System (RSMS) developed for municipal road networks. The RSMS is constituted by a Road Database, an Accidents Evaluation Tool and a Decision-Aid Tool.

The Road Database, which includes all the information about road accidents and the characteristics of the road network, is linked to a linear referencing model that was developed using a Geographical Information System (GIS). The road network model is used to produce maps with any attribute of the road elements, including road accidents.

The Accidents Evaluation Tool is used to compute an Accidents Index for each element of the road network considering the number of cars involved in accidents, the number of fatalities, the number of severe body-injured persons and the number of slightly body-injured persons. The Accidents Index defined for each element of the road network permits the definition of a road element prioritized list.
The Decision-Aid Tool, using the road element prioritized list and the results of safety audits, permits the definition of countermeasures with the objective of reducing road accidents and its impact on the society. The Road Safety Management System was tested using accidents occurred in the municipality of Oliveira do Bairro, dating from 2000. The paper also includes some comparisons between the proposed Accidents Evaluation Tool and others already in use when applying the different methodologies to Oliveira do Bairro’s road network.

The final part of the paper contains a reflection on the main difficulties encountered so far and presents the developments planned for the near future.

**Keywords** – road safety management system, accidents, road database, accidents evaluation tool, decision-aid tool

**References**

The development of China highway intersection safety design manual

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Abstract

Intersection design includes geometric and traffic control. In China, the design warrants are most from “The Technical Standard of Highway Engineering (JTG B01-2003)”, “The Criterion of Highway Route Design (JTJ011 94)” and “Traffic Sign and Marking (GB5768 – 1999)”, etc.

The warrants of these regulations are to meet the demand of capacity and operation efficiency, less of them concern about the safety performance, and potentially it may limit the traffic operations and safety performance in these intersections.

A large-scale research was initiated recently to develop safety design technology of at-grade intersection. The research program contains wide aspects of safety performance design for at-grade intersection, including intersection locating, appraising technology, diagnosis method, geometric design and traffic control design, etc. In order to promote the use of the research achievement, “The Highway Intersection Safety Design Manual” was compiled, and this paper summarizes the research study of the manual.

According to systemic and practical principles, most of the useful research results must be embodied in the manual. The framework and compiling principle of highway at-grade intersection safety design to improve highway intersection safety service level were introduced in the paper. The manual includes knowledge and application contents.

Knowledge contents introduced intersection safety influence factors, safety design basic theory and method, these theory and method must be comprehended and exercised easily by the users.

Application contents provided the design and improve measurement flow according to the intersection planning design and safety improvement respectively. The manual can supply, specify and perfect exiting regulation, and also provide technology support for new planning and exiting intersection. It plays an important part on popularizing traffic design method and making the design technology into productivity, so the manual have significant and applicant value.

As the impact to road safety property is a synthesis result of all importation factors, and it is impossible to quantify the relationship among all the factors.
For example, normally, the left-turn lane added to the approach can improve the safety property of intersection, but in particular situation, the result may be converse. The manual try to avoid bring ambiguity to the users. But, as a tool book, these contents can not be neglected, so the manual prepare some detailed outlines which will be supplemented in the future.

Keywords – highway intersection, traffic safety, design manual

References

Trajectory of vehicles with the aim of designing a real time driver warning device

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Abstract

The work presented in this paper was carried out in the frame of the SARI coordinated project (www.sari.prd.fr) of the French governmental program of R&D for inland transportation: PREDIT in which several French research centres, engineering schools and universities join their resources. Research investigations of SARI address safety of secondary roads. Actually, in France, road accidents, outside urban areas, caused around 4,000 deaths in 2004, which represents around 70% of the total number of people killed on roads in France during that year. One estimates that the risk of fatal accident on secondary roads is 4 to 6 times higher than on main roads and highways.

Metrology of vehicles trajectories has several applications in the field of road safety, particularly in dangerous curves.

Actually, it is of great interesting to observe the trajectory of vehicles with the aim of designing a real time driver warning device in these areas.

Actually, most of the videos systems installed on the road provide only traffic monitoring features to get, for example, average speed estimation helping the managers to better know and optimize their network. Methods used for these applications, coming from an active research [1], [2], [3], used strong constrains offered by the Highway Code context.

Moreover, since the precision is not an important feature for these systems, they are not adapted to trajectory analysis in curve. Also, there are researches about small displacement, but mainly focused on the pedestrians [4].

These trajectories not being subjected to strong constraints, measurements cannot be very precise. So, this work falls under a field where the constraints and the precise details are strong: measurements of the vehicles trajectories in a curve.

In France, two curves of the three dangerous sites identified by road safety experts were instrumented, during two weeks, by a calibrated Observatory of Trajectories (OT) composed with various cooperative electromagnetic | infrared | ultrasound systems and a video system placed along the road.
The best contribution of this paper is the multi-sensor system which has been totally developed for this project and can record three cameras VGA and rangefinder information's. This system can measure the trajectories of each vehicle on one hundred meter long curve. Also this article presents a probabilistic method of accurate vehicles tracking, using a particle filter, a kinematic model close to reality, known as bicycle, and the definition of an observation function based on the reprojection of simplified 3D models of vehicles.

Many trajectories of a vehicle equipped with a kinematic GPS were measured on real sites. These grounds truths make it possible to validate in experiments the result obtained with this algorithm.

A detailed study of the trajectories parameters allow to extract the “abnormal” drivers’ behaviours and then to better understand the drivers’ actions. The final goal of this project is to be able to alert some of the drivers, potentially in danger, by suit message on dynamic sign.

Keywords – road safety, roadside systems, trajectories measurement, kinematic GPS, imaging and image analysis

References
Fuzzy set approach to motorway tolling system optimization

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Abstract

Motorway tolling systems are nowadays a necessity on all motorways around the globe. But there is no unique solution for the motorway tolling system layout, its system architecture and way of implementation. On the other hand, motorway tolling systems differ in effectiveness depending on their characteristics. Motorway layout, traffic volume, tolling policy, telecommunication infrastructure, driver’s habits and behaviors in traffic, organization of motorway concessionaire, enforcement policy applied, etc. influence the type and characteristics of motorway tolling system.

The usual procedure in the determination of an appropriate motorway tolling system is based on the analysis of technical and economic features of potential tolling systems.

This analysis is based on quantitative values of relevant system characteristics, omitting all evaluation criteria which cannot be easily quantified. This approach results in an overestimation of investment requirements and technical features of a tolling system and underestimation of human, behavioral, safety, organization and policy factors.

The paper deals with a new approach to motorway tolling system optimization based on the application of fuzzy set theory, enabling the treatment of not only quantitative but also qualitative characteristics of tolling systems. This gives the ground for application of fuzzy set theory in resolving a threaded optimization problem in uncertain environment.

The new assessment method of fuzzy variables, based on fuzzy subset hold values, has been developed for defining basic fuzzy variables, and based on that algorithm the composition of compound fuzzy variables is defined. Then this method is applied for treatment of linguistic expressions, as values of quantitative criteria involved in optimization procedure, and defuzzification of fuzzy values are (is – ako se odnosi na defazifikaciju) described.

The multicriteria procedure is developed for effectiveness evaluation of various motorway tolling system solutions enabling the treatment of fuzzy and quantitative criteria. All relevant criteria are grouped into economic, technical, organization, safety and behavioral subgroups. The relative importance of each subgroup of criteria and criteria within a subgroup is determined using experts’s linguistic expressions based on application of Delphi method. A special algorithm is developed for fuzzy values treatment introducing the new concept of equidistance of consecutive fuzzy values. Special attention is paid to the safety criteria subgroup and analysis of influence of applied tolling system on the overall safety at the motorway. Fuzzy approach to the various measurements of traffic safety enables treating of variables which can be expressed only in a linguistic form. This approach is applied to defining the best tolling system for the 200-km long stretch of motorway in the northern part of Serbia. Six different tolling systems including a GPS based Free
Flow microwave, combined magnetic tickets and microwave electronic tolling, open and closed tolling systems, vignettes have been considered. Special attention has been given to the treatment of traffic safety, international electronic tolling interoperability and tolling fraud preventions. The behavioural, organization and social impact of applied tolling system has also been studied.

After the optimisation procedure the sensitivity analysis of the results obtained has been performed. The treatment of fuzzy variables is done by Wolfram Research “Mathematica 5” software.

**Keywords** – motorway tolling, multicriteria ranking, fuzzy set, system evaluation

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**References**


A review of international road transport database files with risk exposure data

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Abstract

The objective of this paper is to present the results of a critical assessment review of international databases which include risk exposure data (EUROSTAT, ECMT, UNECE, IRTAD and IRF). In particular, the data collection and analysis as well as the availability and quality of the risk exposure data (vehicle and passenger kilometres, vehicle fleet, road length, population etc.) were investigated.

This work was carried out within the scope of the SafetyNet project of the 6th Framework Program for Research, Technological Development and Demonstration of the European Union [1].

For that purpose, existing surveys administered to the international databases file administrators were analysed [2; 3; 4; 5].

The results were used to define the contents of a follow-up questionnaire. Personal interviews with international database provider representatives were carried out in order to collect additional information on the existing risk exposure data, the procedures for its collection, registration and accessibility. The outcomes of this analysis and interviews are presented and discussed in this paper. The main characteristics of the examined international data files are presented.

Additionally, selected available risk exposure figures (disaggregated) by country and by year are compared amongst the mentioned international data files. An overall assessment of the potential for international comparisons was also carried out [1].

The results show that international databases are useful sources of risk exposure data, especially due to the extent of the available times series data, which is a result of several decades of important data collection efforts. However, the objectives and scope of data collection, as well as the availability and quality of the existing risk exposure data, vary significantly amongst databases. For that reason, it is suggested that the analysed databases may be used in a complementary way.

Significant differences exist in the published figures amongst data files [1]. For example, this is the case for the “most complex” risk exposure measures (e.g. vehicle and passenger kilometres) which present the greater differences. These differences may be explained due to the different national sources and definitions used or to insufficient data quality control within the data files.
Therefore, particular caution is recommended to data users for a reliable use of the information available in road safety analyses.

*Keywords – risk exposure data, international data files, availability, comparability*

**References**

Study on the core technology of static road traffic operation safety management system

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Abstract

In spite of the serious problem caused by road traffic accidents and their consequences, the systematic safety management technology has not yet been established and implemented, especially in developing countries. Road management agencies encounter a number of difficulties in safety management decision making that include identification of accident-prone locations, diagnosis of safety problems and treatment selection, prioritization of improvement needs within existing limitations in resource availability [1]. In addition, if the size and various road classes of a typical network are considered, the need for a systematic management methodology becomes imperative.

Generally speaking, road traffic operation safety management includes two kinds of works: static management and dynamic management. The static management means implementing the management works during a period of time, such as the operation safety plan of road network, the periodic safety assessment and improvement of road network. The dynamic management means the real-time surveillance and control to road safety, such as accident prevention in bad weather and the succor works after the occurrence of accidents. In the beginning of this paper, the function of the static road traffic operation safety management system was analyzed and the framework of it was established on the basis of numerous research works on road traffic safety and relevant management theories. In the main body of the paper, the core technologies of the system were studied, including the road traffic operation safety evaluation, prediction and decision-making technologies.

Considering accident types and patterns as well as roadway and operating characteristics differ among road sections with different road and traffic characteristics [2], road network was divided and classified into different kinds of units according to functional characteristics, e.g. traffic volumes, design features. Each section type was treated separately in operation safety management, including safety evaluation, prediction, and improvement decisions.

According to the request of static road traffic operation safety management, considering both pre-accident and post-accident evaluation, the evaluation index system composed of three categories of indices, i.e. the accident index, traffic flow characteristics index and road facilities characteristics index, was established. Due to the fuzzy character of road safety problem and the limitation of the classic set theory [3], the fuzzy logic theory was applied to study the safety evaluation model, combined with advanced data mining and data fusion technologies.

The evaluation model was established by analyzing the intrinsic relation among accident data, traffic flow characteristics, road facility characteristics and operation safety conditions. Road traffic system has the typical non-linear characteristic and uncertainty for the interaction among inner and outer factors. Based on
the dynamic movement rules of the road traffic safety condition, the prediction model was studied by the application of Time-series prediction method and Markov theory.

Then the identification method of road traffic operation safety condition was put forward based on quantitative evaluation and prediction results. On this basis, the decision-making technology of static road traffic operation safety management was studied by adopting optimization method and dynamic programming method.

*Keywords* – road safety, static management system, evaluation, prediction, decision-making

**References**

The influence of shortcomings in the 3D alignment on the traffic safety

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Abstract

Road design performed by highway planning authorities and planning offices is carried out in the three separate levels the horizontal and vertical projections and the cross-section.

Experiments have shown that even when norms and thresholds outlined in standard works are followed, shortcomings in the 3D alignment may still occur when the horizontal and vertical projections are processed separately and then harmonised. Shortcomings of this kind can particularly cause accidents on two-lane rural roads. Drivers may start an overtaking manoeuvre, although they cannot see part of the road, and are then no longer able to interrupt the procedure when oncoming traffic suddenly appears [1].

As drivers absorb images from a central perspective when driving along a road, it makes sense to calculate virtual perspective views using suitable visualisation modules and then use them to check the 3D alignment. Unified model assumptions that match the driver’s vision must be set to ensure the comparability of the central perspective views [2]. If a driver is unable to recognise a section of the road in the driving area ahead, this gives rise to blind sections. Critical blind sections exist if the driver is unable to recognise a section of the road at least 75 m long along the road ahead (600 m), where the depth of the blind section is greater than 0.75 m. If critical blind sections occur in the 3D alignment, these are either called “jumps” or “dips” in a section of road, depending on their optical appearance. In both cases, part of the road is concealed from the driver and is not visible. If an inflection point in the horizontal projection lies at a point where there is a crest, the driver’s view of the beginning of the bend may be concealed. The sudden change in direction then takes the driver by surprise. A concealed beginning of a bend occurs if the route ahead cannot be seen from 75 m before the beginning of the bend, at least up to the point where there is a change of direction of 3.5 gon [3]. So when setting a route, it is vital to guarantee that the beginning of the crest section, which the driver cannot see, is further away from the driver than the point where the change in direction takes place.

With the help of a blind section ligament the design engineer get the quantitative information in which parts of the road critical blind section are existing (red-line-section).

If a driver cannot see the road ahead for a fairly long section, irregularities in the road surface may give the driver an unbalanced sense of alignment. This also occurs when the horizontal and vertical projection elements are superimposed in an unsuitable manner. These kinds of shortcomings are not relevant to safety, but should largely be avoided for aesthetic reasons.
A methodology has been developed to check the 3D alignment for shortcomings in three basic stages (checking for standard 3D elements, for safety-related shortcomings and design shortcomings) [4].

Keywords – 3D alignment, shortcomings, critical blind section, concealed beginning of a bend, checking methodology

References
Modelling human behaviour by multidimensional and numerically described probability distributions

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Abstract

Safety is one of the most important factors to be taken into consideration when designing road infrastructure. Therefore it is necessary to analyze the complex road traffic system to describe the influence of the parameters (e.g. human behaviour, infrastructure, natural influences, legal factors etc.) on safety. The researchers have to understand the cause-and-effect-chains from influencing parameters to accidents. For analysing the cause-and-effect-chains in accident research, the human behaviour is one of the most important parameters, but very difficult to integrate into the analysis. Experience shows, that, because of many uncertainties and dispersions of human behaviour, the characterizing parameters should be described not by singular values but by probability distributions.

The presented method allows to describe values (e.g. describing human behaviour) by probability distributions even in relation to other values, which are also described by probability distributions, thus giving multidimensional statistical distributions. This allows to minimize dispersion by grouping e.g. the drivers and their exposition by certain parameters as motivation, age, experience, weather or sight conditions.

The cause-and-effect-chains leading to accidents are described by models, which have a modular structure describing the parameters by active and passive elements, and allow to predict the probability for damage in relation to its extent. If their predictions do not contradict reality, the models can be used to identify points of weakness in traffic safety or to evaluate positive and negative effects of measures. The different modules of the models can be worked out and refined nearly independently by different research groups even from different disciplines.

Each research group can concentrate on the modules it is especially interested in and use the models to interact with other researchers and modules.

The passive elements (interfaces) describe certain state variables, (possibly) in relation to system parameters or variables of other passive elements. They are generally described by multidimensional probability distributions.

The active elements (modules) describe, how the state of the result interface is derived from the values of preceding interfaces.

These rules may be described by multidimensional probability distributions (e.g. in psychological context) or by arithmetic formula, whose parameters itself may be variables described by multidimensional probability distributions (often in technical context).
The multidimensional probability distributions themselves are described numerically, allowing to follow every form of distribution, as the complex and non-linear relations are seldom similar to standard distributions. The numerical description is an approximation technique which is experienced for solving many problems in the field of technical engineering. Each distribution may be built of a huge number of values (which in general is hidden from the user except for input and final output). A tool for “calculating” with variables described in this way is provided.

The method is based on existing technologies, and shall help to model the system road traffic considering human behaviour, therefore to allow to calculate the risk on traffic situations and so identify critical situations.

**Keywords – traffic safety, human behaviour, modelling, interdisciplinary work, numerical description**

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**References**

Driver perception of horizontal curvature in sag vertical curves

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Abstract

Driver visual perception of the road has long been considered a very important issue in human factors research. Confusing or misleading visual cues may result in erroneous driver operation and increase the risk of accident. Since driver behavior and performance is mostly determined by subjective driver perception of the road environment and not by the existing values of highway geometric design elements (e.g. exact values of horizontal curve radii, longitudinal slopes, superelevation, lane width etc.), investigating driver perception of curvature can be considered a fundamental issue in three dimensional highway geometric design. It is therefore very important that road design engineers learn to see the highway in the eyes of the ordinary driver and that designing with the user in mind is reflected in highway geometric design guidelines [1].

This research focuses on the issue of driver's misperception of curvature of a horizontal curve, when overlapping with sag vertical curve.

Smith and Lamm [2] first hypothesized that in sag vertical curves superimposed with horizontal curves (which may result in perspective views which make the horizontal curve appear flatter than in reality) higher operating speeds can be expected and often higher accident risks. This hypothesis has been verified by researchers [3; 4] who presented drivers with computer animations of horizontal curves superimposed with sag vertical curves and examined the reported perceived radius.

In addition, researchers [5] have attempted to determine the amount of radius underestimation in horizontal curves overlapping with sag vertical curves.

However, closer examination of the above findings and of the employed methods reveals that further research is still necessary in order to fully understand the parameters (both parameters of road geometric design and driver characteristics) affecting driver misperception of curvature of a horizontal curve, when overlapping with sag vertical curve.

In this research, a suitable experiment has been designed, based on a "Graeco-Latin Square" statistical design. Photorealistic computer animations of horizontal curves superimposed with sag vertical curves, with preselected geometric design parameters (according to the "Graeco-Latin Square" statistical design), were presented to a sample of drivers. Photorealistic animations of similar curves superimposed with flat profile were presented as reference curves, and the drivers were asked to compare the two curves with regard to their horizontal curvature.
The paper discusses the findings of the above study, regarding the parameters affecting the probability of erroneous perception of curvature and how changes in the values of these parameters are reflected to the probability of misperception of curvature of a horizontal curve, when overlapping with sag vertical curve.

Keywords – highway design, three-dimensional analysis, alignment, curvature, driver behaviour

References

European research programmes HUMANIST and COST 352 safety research: roles, effects and acceptance of advanced assistance and information systems in safety promotion and injury prevention

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Abstract

The study of driver behaviour is essential to the safe implementation of new traffic control systems. Into this context of increasing demands placed on drivers in a complex environment, vehicle manufacturers are introducing a broad array of new technologies. Whilst the motivation is driver comfort, there are plenty of opportunities, and pitfalls, for safety that this new technology provides.

It is clear that the development and supply of In-Vehicle Information Systems (IVIS) is not taking place in a context of discovering and providing for the information handling capacities of drivers. In addition, the increasing use of mobile phones, GPS based navigation systems and even DVD in cars is almost certainly leading to accidents.

Vehicle manufacture and the development of techniques such as intelligent speed adaptation take place on a European-wide basis. It is vital for policy makers, both in Government and Industry, to understand the individual and cumulative effects of this growth in IVIS on the capabilities of drivers to manage their vehicles in safety.

HUMANIST Scientific Scope:

Road telematic and driver assistance systems can constitute a real opportunity to support mobility and to improve road safety. Nevertheless, it is necessary to conceive them according to users' needs and requirements, in order to ensure their acceptability and to detect potential harmful effects of their widespread use.

Human factors and cognitive engineering competencies exist in Europe but are scattered. For addressing this fragmentation of research capacities, HUMANIST gathers the most relevant European research institutes involved in Road Safety and Transport to contribute to the eSafety initiative and to improve road safety by promoting human centred design for IVIS and ADAS.

This integration will allow us to increase Societal Benefits of ITS implementation, to harmonise ITS approaches among State Members, to react quickly to any new technological developments and to face international challenges by producing state of the art research, identifying knowledge gaps, avoiding redundancy of research activities.

The goal of HUMANIST is to create a European Virtual Centre of Excellence on HUMAN centred design for Information Society Technologies applied to Road Transport (IVIS and ADAS), with a coherent joint program of activities, gathering research, integrating and spreading activities.

Integrating Activities will permit us to manage and to consolidate the NoE structure by promoting the mobility of researchers, by optimising the pool of existing experimental infrastructures, by setting up electronic tools (common database, web-conference, e-learning) for knowledge sharing.

Spreading Activities will allow us to spread widely the knowledge from HUMANIST, by organising debates with RTD projects on eSafety and relevant stakeholders, by promoting harmonisation with standardisation.
and pre-normative bodies, by setting up training programmes, and by promoting and disseminating research results to a wide audience.

Keywords – human machine interface, IVIS, ADAS, driving task, human factors

References

7. Pipa, Martin. Intelligent Car Initiative. ITS@revue, 2006, roč. 6, č. 10, s. 5-6. ISSN 1213-4430.
10. Schmeidler K.: Selhání lidského činitele v silniční dopravě, POLICISTA, Ministerstvo vnitra ČR, strana 16-18, 2 fotografie, číslo 3, 2005
13. Schmeidler, K. ITS support of ageing drivers generation. In 18th ICTCT workshop on Transport telematics and safety: Technical, social and psychological aspects, Helsinki, October 27th and 28th, Finland, 2005, organized in co-operation with VTT and AIÖ programme, abstrakt na stránce 63 sborníku, plný text vydán na cd-rom
Human factors research and road safety in the Czech Republic

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Abstract
This is the first time the Czech Republic Government has decided to do something with the burdensome situation of Czech road safety. The number of fatalities and extreme material losses caused by accidents has forced legislators to amend the legal code and related decrees pertaining to road traffic. Since Saturday, the 1st of July, 2006, road traffic rules have been altered significantly. Due to the fact that numerous surveys, as well as foreign experience, have shown that the greatest opportunity for a reduction of accident and death rates on the roads lies in the approach to the ‘human factor’, legislation with regard to traffic on Czech roadways has changed appreciably. Harsh legislative amendment to traffic law has introduced the point system, much higher fines, and other changes that should enhance safety on Czech roads. The driving public had an urgent need for relief from chaos on the roads and from obsolete rules that were unable to inhibit flagrant infractions by maniacs in over-powered cars or the passive disregard of those who risk their lives and the lives of their children by leaving seatbelts unbuckled.

Background:
Drivers in the Czech Republic rank among the worst in Europe. Each year in this country there are 130 road accident fatalities for every one million inhabitants. Czech drivers are unruly, and cannot drive well because they lack the experience of their foreign colleagues. They are nasty, aggressive and unafraid of sanctions. In the ten years following 1993, there were two million traffic accidents in the Czech Republic, which killed about 14 thousand people. Damage to property has exceeded 65 billion crowns. On average, every 2.7 minutes an accident is reported to the Czech Republic Police; every 18 minutes, there is a minor injury; every 96 minutes a major injury is caused by accident; every 6.7 hours a victim of a road accident dies. Every hour, damage caused to property exceeds one million Czech crowns.

In comparison to modernized countries with large motoring public, road safety is still not given priority by Czech society. Awareness of operating rules is extremely low among road users as compared to that of the more developed countries, as is the level of law enforcement.

During the 1990’s, the unsatisfactory state of road safety earned limited acknowledgement from the traffic authorities. The prognostications of a small group of experts were not taken into consideration. Although the authorities approved their proposal for the introduction of certain measures, no support funding or legislative background was ever created to respond to those predictions. Road accidents and their consequences were considered an inevitable corollary of motorization, freedom of mobility, and new life styles. The government only began to implement basic, short-term, remedies in 1998, in response to receipt of tragic statistics from 1994. The programme focus is aimed at the necessary improvement of current structures and practices. In order to reach its main target – an annual reduction of road fatalities by 5 per cent – the programme summarized tasks for each partner of the National Road Safety Council. From its inception this was designed as a temporary action and a need for a further long-term strategic programme has been evident.
Despite certain positive results reached by the Action Programme in 1999 and during the first quarter of 2000, it has become increasingly clear that the road safety programme cannot be formulated as a summary of relatively independent activities by the bodies involved. Its main insufficiency is shown in the limited decision-making authority of the National Road Safety Council. The current system of funding, without any co-ordination by the Council, is especially inoperable. One of the most flagrant examples of the contradiction between principles and practice is the emphasis placed on the importance and efficiency of engineering measures in the face of constantly decreasing maintenance budgets for the Road and Motorway Directorate. The current situation can be remedied only by means of a co-ordinated approach in the prohibition and prevention arena, including the passage of a number of essential amendments to the law covering road freight transport. An essential precondition to the success of the proposed strategy is the active participation of all the entities concerned including: state authorities; public administration; businesses engaged in transport; non-governmental organizations and civic associations; and support for the project as a whole from the general public. An interdepartmental working group comprised of representatives of the state administration has drawn up the National Strategy for Road Safety. Additional experts and representatives of the public administration were invited to take part in proceedings in which their thoughts, ideas and comments were welcomed. The proposed strategy is based on:

- Deep analysis of the development of road accidents in the Czech Republic
- The legal regulations in force in the Czech Republic
- The current powers of the public administration and its standard of performance
- SWOT analysis of the road safety situation
- The international obligations of the Czech Republic
- The transport policy of the Czech Republic

References

2. Cauzard J.P. Pro vyšší bezpečnost a lepší řidiče na našich silnicích, vybrané výsledky evropského výzkumu, Sartre výzkum 1998 – 2005 o sociálních postojích k rizikům silniční dopravy v Evropě, INRETS a CDV Brno, sekce sociálních a humanitních problemů v dopravě, 2004
9. Schmeidler, K. ITS support of ageing drivers generation. In 18th ICTCT workshop on Transport telematics and safety: Technical, social and psychological aspects, Helsinki, October 27th and 28th, Finland, 2005, organized in co-operation with VTT and AINO programme, abstrakt na stránce 63 sborníku, plný text vydán na cd-rom
Measuring forces and displacement ranges used by drivers in normal driving conditions

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Abstract

There are a high number of different factors that are directly related to road safety. Human movements and behavior is one of them, and more specifically the movements and forces of the driver.

Nowadays, there are not clear values of what movement range and strength are needed in a safety driving, being this a critical issue for mobile impairment users. These users, which usually need adaptations in order to drive safety, haven't got objective criteria that can be used in their evaluation procedures. In Spain, the reference values for displacement ranges are introduced in the psychological-medical exploration procedure [1], which is based in a research made 30 years ago [2].

The Automobile Laboratory of the Polytechnic University of Valencia, in conjunction with FIAT Spain and the Spanish Traffic Administration, has developed a project which aims to obtain those values. In order to archive this, a vehicle has been sensorized with different instrumentation. The installed sensors include pressure sensors in the break pedal and the clutch pedal, displacement sensors in the accelerator pedal and also the clutch pedal, alongside with angular displacement and torque sensors in the steering wheel. Other values, like the position of the gearshift, velocity and acceleration, etc have also been measured in the vehicle. Moreover, the movement of the driver's elbow, wrist, knee and ankle has been measured with angular displacement sensors. Secondly, a number of 24 different drivers have been selected, with distinction of sex, age and height. Those drivers performed several exercises in a closed circuit. Those exercises included parking and normal driving situation.

Finally, the stored data has been analyzed, showing the results with different kinds of graphics and tables. At the end, conclusions have been reached about the driver's movement ranges and strength.

Those values will help to discover which drivers are able to drive safely, physically speaking, and which drivers need special examination, maybe even technical adaptations.

Keywords – driving conditions, muscular strength, range of movement, driving assessment
References


The impact of penalty points on the behaviour of young Spanish drivers and passengers

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Abstract

In the European Union road traffic is one of the main causes of death amongst young people. More than 5,000 people aged between 18 and 24 years old die every year in the E.U. and nearly 1,000 of these deaths occur in Spain [1].

The use of penalty points on drivers’ licenses is one legislative method of reducing road accidents. This measure has been used in a number of other countries, including the United Kingdom, France, Germany, Italy and Luxemburg, resulting in reductions in their accident rates. In Spain, the new “Penalty Point” law was introduced in July 2006. Six months after the implementation of the law, accident rates have been reduced by 14.3% [2].

The aim of this study was to analyse changes in the behaviour of a large sample of university students after the implementation of the penalty point license law in Spain.

The sample consisted of 644 university students (41.1% males), aged from 18 to 30 years old ($M = 20.7$; S.D. = 2.4). Four behaviours were analysed: driver speed, cell phone use while driving, drink driving, and seat belt usage.

The results suggest that the participants increased their safety behaviours after the introduction of the penalty point law. Seat belt use amongst rear seat passengers was the behaviour which increased the most, with more than 20% of participants using the seat belt in the rear seats more often. There was also a 10% increase in the use of front seat belts while travelling on urban roads, and 2.4% while travelling on the highway. Drink driving behaviour and cell phone use while driving decreased 8% and 9%, respectively, after the introduction of the penalty point law. Furthermore, exceeding the speed limit decreased by 2% on urban roads and 5% on the highway. However, the reduction in driver speed on urban roads was not significant.

Therefore, the introduction of the penalty point law seems to have had a significant effect on the risky behaviours of young drivers and their passengers, but this effect was not the same for all behaviours. This paper discusses the implications of these results for future campaigns and other actions necessary to improve the road behaviour of young people.

Keywords - penalty points, driver behaviour, spanish drivers
References


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Safety analysis of car-only lanes

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Abstract

One of the promising safety measures widely discussed for real-world implementation is the separation of trucks from other vehicles namely by using truck-only or car-only lanes. For example, New Jersey Turnpike has car-only lanes as well as car and truck mixed lanes between exits 8A and 15E. As stated in [1], the major objectives of the truck lane separation can be summarized as:

1. Safer roadways for passenger cars.
2. Construction cost savings for roadway designs implemented specifically to reduce certain types of accidents such as roll over or truck overturn accidents.
3. However, the benefits of assigning dedicated lanes for trucks have not been clearly documented in the literature. Few studies that have been conducted in the past show some contradictory results depending on the study region [1,2,3,4,5].

In this paper, following the first objective of improving safety by separating cars from trucks, a brief summary of accidents statistics on the New Jersey Turnpike (NJTPK) will be presented to analyze the safety impacts of lane separation. The reason for choosing NJTPK is simply its uniqueness.

NJTPK is a toll road starting from the New York State border in the North, crossing full length of the State of New Jersey down to the Pennsylvania border in the south. Majority of NJTPK (which has a total length of 122.1 miles) has mixed lanes where cars and trucks use the same lanes. However, approximately 35 miles of the facility has eight lanes where 4 of these lanes are car-only (inner) and the other 4 are car-truck mixed (outer) lanes.

In this section, trucks are not allowed to use the inner lanes except very few occasions during the year. NJTPK is a closed system in which the entries and exits to the system are controlled through toll plazas. Since the geometric road characteristics of the separated lanes are almost the same, NJTPK provides a perfect opportunity to assess and compare various safety impacts of truck lane separation for the same controlled-access facility.

The datasets used for the analysis are NJTPK incident log data and New Jersey Department of Transportation (NJDOT) crash database. The major difference between the two datasets is that NJTPK data includes both disablers as well as accidents whereas NJDOT data set has accidents only. On the other hand NJTPK data has the incident duration and emergency response information that is not available in the NJDOT database.
The preliminary analysis results based on one year data show that, truck involvement does not necessarily imply more severe accidents.

The aim of this current study is to conduct a more focused analysis using “multiple year accident” data along with accurate traffic volume information which, is generated using individual vehicle volume and speed data collected by the NJTPK authority.

Other relevant information such as inclement weather, work zones, etc. is also exploited to make inferences about the benefits of truck-car lane separations. The unique structure of NJTPK facility, having both car-only and car-truck mixed lanes along each other, allows a perfect experimental analysis setup to make inferences about the safety benefits of this kind of separation.

**Keywords – incident analysis, safety, lane separation, truck accidents, statistical analysis**

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**References**

Development of a clinical assessment tool
to predict fitness to drive in people with Parkinson’s disease

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Abstract
Patients with Parkinson’s disease (PD) suffer from progressive motor, cognitive and visual processing
deficits that may have an impact on safe driving behaviour.

In Belgium, physicians are required by law to report people who do not meet the minimal medical standards
of safety to drive a car to the local authorities. Their assessments are mostly based on a medical examination
and a driving history questionnaire. They are therefore at best only moderately predictive of driving
performance as evaluated by driving experts.

The main aim of this study was to develop a short screening battery, which could assist physicians in the
assessment of fitness to drive in people with PD.

A second aim was to determine the additional value of a driving simulator in the prediction of fitness to drive
[1].

Forty regularly driving PD patients with no limitations on their driver’s licence participated in the study.

Based upon extensive literature review, we selected the Motor Part of the Unified Parkinson’s Disease
Rating Scale (UPDRS III), the Clinical Dementia Rating (CDR), Pelli-Robson contrast sensitivity (CS) and
disease duration amongst some other tests for inclusion into the clinical assessment battery.

PD drivers were also referred to CARA for an official driving assessment, which involved a medical
screening, visual and neuropsychological tests and an on-road evaluation. After the CARA assessment, PD
patients were categorized in (1) fit to drive without any restriction or (2) fit to drive with restrictions/unfit to
drive.

Twenty-nine PD (72.5%) patients were classified as ‘fit to drive without any restriction’ while 11 (27.5%)
patients were judged as ‘fit to drive with restrictions (N=10) or unfit to drive (N=1)’.

Discriminant analysis revealed a predictive equation that correctly classified 36 (90%) of the 40 patients,
with a specificity of 91% and a sensitivity of 90%:

\[(CS\times16.95) – (CDR\times4.17) – (UPDRS\ III\times0.16) – (disease\ duration\times0.33) – 23.49\]
A positive score indicates that the patient can continue driving without restrictions. Patients with a negative score need to be referred to CARA.

To determine the additional predictive accuracy of a driving simulator evaluation, we first established the discriminant ability.

Therefore, differences in driving simulator performance between the 40 PD patients and 40 age and sex matched controls were investigated.

PD patients had a significantly lower total driving simulator score, had more traffic tickets but were not involved in more accidents as compared to their healthy peers.

When the total driving simulator score was entered into the discriminant analysis, we derived a formula that correctly predicted 39 (97.5%) of 40 PD patients with a specificity of 100% and a sensitivity of 90%:

\[
(\text{Driving simulator score} \times 0.29) + (\text{CS} \times 12.38) - (\text{CDR} \times 2.49) - (\text{UPDRS III} \times 0.15) - (\text{disease duration} \times 0.29) - 46.54
\]

We can conclude that we have developed a short clinical screening tool, which is fairly easy to administer and can be completed within the consultation routine of the physician. If the score is below zero, referral to CARA seems to be the right course of action.

Keywords – Parkinson’s disease, fitness to drive, clinical examination, driving simulator

References

The safety effects of median treatments on rural freeways in the United States

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Abstract

Due to the gradual increase in traffic volumes, existing rural freeways need to be widened from four to six lanes to adjust the additional travel demand. The first choice of new lanes location is within existing medians to avoid high costs of land acquisition and bridge structures. The impact of narrowing medians and installing new median barriers are not sufficiently investigated. This paper presents results of nearly three-year research.

Traffic, geometry, and crash data have been collected from eight states in the United States. Although a special attention has been given to median treatments (median width, median elevation design, presence and type of median barriers) additional data including traffic volumes, speed limits, percent of track, horizontal and vertical alignments and number of lanes were collected to control these factors when estimating the safety impacts of median treatments.

The impact of median treatments on crash frequency was investigated through Negative Binomial regression and before-and-after studies. The impact on crash severity was investigated with a logit model. The presented study did not follow most of the past work where the overall impact of roadway geometry on crash frequency and severity was quantified [1-4]. We have assumed that median changes may affect frequency and severity of different types of crashes differently. This assumption was found correct. Separate effects of changes in median geometry have been quantified for single vehicles (SV), multiple vehicle same direction (MVSD) and multiple vehicles opposite direction (MVOD). These results are significantly different.

This presentation focuses on selected methods of widening rural freeways including additional lanes outside of the median, additional lanes inside the median without installing barriers and with installing concrete barriers [5].

The paper presents the obtained statistical models and crash modification factors and discusses the results. The results indicate that adding lanes without affecting the median increases the severity of crashes to a limited extent. Reducing the median width without adding barriers (the remaining median width is still reasonably wide), shifts the frequency from MVSD crashes to SV and MVOD crashes. The severity of crashes increases in all crash categories; particularly in the MVOD crashes. Reducing the median to 9-15 meters and installing concrete barriers eliminates the MVOD crashes and shifts the frequency from MVSD to SV crashes and increases severity of these two crash categories.
The results enable estimating the costs of alternative solutions and will help locate new lanes and select most beneficial median treatments on widened freeways.

**Keywords** – safety, freeway, median, design, regression, logit model

**References**

Research on real-time safety appraisement
of freeway network

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Abstract
Freeway network is basically formed by the coalescence of many segments with the topological relationship. Thus the whole network safety is closely bound up with the related segments. Factors to highway safety for all-circumstance are large and complex and these factors often possess fuzziness which makes calculation difficult.

The paper advanced fuzzy comprehensive judgment which can synthetically take the facilities and environment into account. On the basis of segments safety service rank evaluation, the network evaluation model is formed which can be employed to evaluate the network real-time safety by inputting traffic and weather information.

The paper is committed to study real-time safety of freeway network on the basis of fuzzy comprehensive judgment of segment safety. The factors that affect real-time safety of freeway network, such as highway facilities, traffic engineering facilities, traffic management facilities, weather conditions and traffic environment, [1; 3] have been hierarchically divided, and fuzzy judgment matrix has been established on the basis of specification and certain statistic data.

According to the research product of forerunners and basic mathematical statistics data on - the - spot at home and abroad, the single factor’s importance matrix is determined. Then using APH, specialist-scored method and trapezoidal membership function, weight of each factor is determined. Multi-objective model is established.

Two-level fuzzy comprehensive judgment is made to evaluate safe service rank of segment operation. Using analytic hierarchy process, specialist-scored method and trapezoidal membership function, [2] weight of each factor is determined. Two-level fuzzy comprehensive judgment is made to evaluate safe service rank of segment operation. And then freeway network’s safety is determined by the weighted sum of segments. During the determination of weight, the important degree of the segments in the network should be fully taken into account and AHP could be employed. For ordinary segments, the importance order could be ascertained by comparing the significance to the network and the history traffic volume on the segment. Then weight could be determined by means of APH. In addition, the paper prepared an example to explain the course of judgment.

Keywords – freeway network, real-time safety, safe service rank, analytic hierarchy process (AHP), fuzzy comprehensive judgment
References

Mobile phone use while driving: a major public health problem in an Arabian society

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Abstract

Many researchers believe that the distraction caused by the conversation is the primary source of distraction whereas the physical task demand of mobile phone use (e.g. answering a call, dialing a number, holding hand-held mobile phones) is only a secondary source of distraction and possibly not related to accidents [1].

Other countries, such as those Arabian states, which have developed rapidly over the last 50 years, are under-represented in the research literature and the cultural aspects and differences in mobile phone use while driving have remained totally unexamined.

The aim of the present study is to assess the frequency of mobile telephone use while driving in a sample of road traffic victims, and to determine what factors predict mobile telephone use in Qatar. Structured interviews were conducted and participants were asked to complete a questionnaire concerning socio-demographics, driving attitudes and behaviour, adherence to traffic laws and mobile phone use. Qualified Nurses and Health Educators were instructed to structurally interview and complete a questionnaire for randomly selected Qatari men and women drivers.

The study was conducted from December 2004 to June 2005 during which 1139 drivers were asked to participate in the study and 822 drivers expressed their consent and met the inclusion criteria with a response rate of 72%. Of 822 drivers included for the study, 602 (73.2 %) of drivers used mobile phone while driving. Of 602 drivers, 497 (82.6%) used hand-held mobile phones without any extra add-on equipment.

The present study showed that mobile telephones are becoming increasingly popular communication devices and adolescent drivers have been identified as a particularly high-risk mobile phone user group in the State of Qatar. Also vehicle type (4WD vs. small car), excessive speeding, educational level, and running a red light were statistically significant predictors for motor vehicle crashes relate to mobile phone use while driving. This is consistent with other reported studies in Western countries [2]. A stepwise logistic regression analysis showed that vehicle type, excessive speeding, educational level, crossing red signal were significant
predictors for mobile phone use while driving. Delayed reactions to change in following distance have been reported in several studies [1; 3]. Recent results by Hancock et al. [4] indicated that phone use seriously impairs crucial stopping decisions. Furthermore, hands-free equipment, although now obligatory in many countries, does not seem to offer essential advantage over hand-held units [5].

In conclusion, use of mobile phone while driving in Qatar is very high and poses a high risk for violations and motor vehicle crashes. These conclusions are discussed with reference to current interventions and safety regulations that are being launched. The traffic safety department should target specific risk groups such as drivers with low levels of education and the young age drivers. This study also provides baseline measures of risky mobile phone use in Qatar and will, therefore, help in evaluation of current interventions and safety regulations that are being launched.

Keywords – mobile phone, driving, road traffic crash, risk factors, violation, Qatar

References

Driver behaviour and accident involvement: state of Qatar

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Abstract

Traffic accidents can be attributed to human, vehicular, and environmental factors [1]. When considered alone, human factors account for about 57% and together with the other factors (vehicular and environmental) about 92% of automobile accidents. Many researchers have looked into the relationships between socio-economic factors and accident involvement. Among these factors, age has been found to be one of the highest correlates of accident involvement followed by gender. Men are prone to sensation seeking and consequently display reckless driving [2]. Men also have a higher degree of risk acceptance while driving [3] and do not hesitate to drive under difficult situations like driving in bad weather or late at night.

The aim of the present study was to examine the effect gender on driver behaviour and accident involvement in the State of Qatar.

Fifteen hundred drivers were approached and 1110 agreed to participate. Participants completed a questionnaire including socio-demographic information, Driver Behaviour Questionnaire (DBQ)[4], Driver Skill Inventory (DSI) [5], and seatbelt use. The study revealed that more than half of the studied Qatari drivers (76.3%) were males while (23.7%) were females. Analyses showed that females reported a higher number of violations, and lapses. No significant association was found between male and female drivers in terms of errors. Six driving skill items also indicated statistically significant differences between male and female drivers. Adequate preventive measures are needed to reduce the road accidents and their severity.

It is observed that six driving skill items indicated statistically significant differences between males and females like “driving behind a slow car without getting impatient”, “managing the car through a skid” “fast reactions”, “overtaking”, “controlling to the speed limits”, and “reverse parking in a narrow gap”. When history of accidents were assessed women were more likely to involve in parking accidents and pedestrian accidents with high statistical significant difference.

Even though most of the men were involved in rear end collisions, overtaking and intersection accidents but did not show any statistical significant difference when compared to females. Male drivers reported RTA nearly four times as much as females.
Among the drivers who did not make accidents, the proportion of males was only two times that of female drivers. This shows that male drivers are more prone to accident involvement. A further part of the gender difference in crash involvement is that the average male drive has higher annual mileage than the average female drive. Adequate preventive measures are needed to reduce the road accidents and their severity. The challenge for public health professionals is to determine suitable strategies to modify risk-taking behaviour in young and male drivers.

Keywords – mobile phone, driving, road traffic crash, risk factors, violation, Qatar

References

Multimodal transport axis design: simulation tool to forecast effects depending on corridor layout settings

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Abstract

Planning an integrated network of European transport infrastructures (multimodal transport gateways), where both transport lines and junction coexist, problems related to the connection of pre-existing infrastructural and natural network aren’t often duly evaluated. This consideration moved from Authors’ design experiences on many segments of AV/AC Italian railways. These experiences showed involvements and consequences of preliminary layout and alignment choices on complementary works; their role is very important to solve the interference between pre-existent networks and the new infrastructures system, mainly road and hydraulic networks.

Design problems, building costs and complementary works’ relevance are often comparable to or even greater than the ones concerning the new gateway infrastructures.

Concerning the design of a multimodal corridor, composed of an AV/AC Italian railway and a highway, the resolution of interferences with the local road-network using crossover works has been analyzed.

In this particular case, starting from an analysis of design solutions, a relationship was identified between the solution itself and a set of system variables, representing the corridor layout: geometrical features and number of infrastructures considered, inter-axis, horizontal and vertical alignment, etc.

It was also possible to identify a set of parameters, which enable the representation of the interferences’ impact; these parameters were expressed as mathematical functions which were used to create a modeling methodology for measuring and forecasting the intensity of identified interferences. In order to consider effects depending on every type of critical matters due to closeness of linear infrastructures, this is the first step in the creation of a global forecast model which should help both stakeholders and designers.

The first ones while planning and evaluating the opportunity of realizing a corridor or not

The second ones during the choice of the best corridor layout in terms of general use of resources, economical and not.

Keywords – multimodal corridor, forecast model, over-passing structures
References


A survey of beliefs, attitudes and behaviours relevant to the impact of audio-tactile lane-marking on road trauma

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Abstract

Audio-tactile lane marking [ATM] is designed to alert inattentive or impaired drivers when they deviate from their lane. Research indicates that ATM reduces crash rates. However, research into psychological mechanisms underlying the efficacy of ATM is limited. Further, ATM may increase perceived safety, and so, according to risk homeostasis, increase risky driving.

We surveyed 775 randomly selected drivers (58% male, aged 18 to 75+ years, median age 41-45 years) regarding their experience with and beliefs regarding ATM.

Ninety-five percent of respondents reported having driven over ATM. Of these, 93% performed a safe correction in consequence, 2% performed an overcorrection, and 2% left the roadway. 30% of respondents believed that ATM had prevented them from running off the road at some time.

Forty-four percent of respondents believed that ATM is easier to see in wet weather compared to painted lines, whereas only 6% believed the reverse. 89% of respondents felt that ATM assists with lane-keeping in wet weather, at night or when they are tired. With these perceived safety benefits of ATM may come increased risky driving (according to risk homeostasis theory).

However, results somewhat allayed this concern. ATM was reported to increase the likelihood of driving whilst fatigued by 8% of respondents, but to decrease it by 16%. Only 1% of respondents felt ATM would encourage faster travelling speed, whereas 9% felt ATM would discourage faster speed. Further, correlations of perceived efficacy of ATM with frequency of driving whilst fatigued and with frequency of speeding did not support risk homeostasis theory.

Over 90% of respondents reported being careful to avoid driving on ATM. Each of 3 negative consequences of ATM (damages tires, damages suspension) causes driving too close to centreline) were identified by 13% of respondents.

Overall, these survey findings are consistent with research indicating the efficacy of ATM, and suggest that it assists with lane-keeping. ATM may reduce risky driving, rather than increasing it as might be expected from risk homeostasis theory.

Keywords – audio-tactile lane marking, rumble strips, risk homeostasis
An implicit non-self-report measure of attitudes to speeding: development and validation

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Abstract

Speeding is a major contributor to road trauma, and is thought to be influenced by attitudes toward speeding. Attitudinal research is limited by reliance on self-report measures and the attendant possibility of reporting biases.

The Implicit Association Test (IAT; [1]) measures attitudes without reliance on self-report, by assessing the association between a target-concept and an evaluation. Participants are shown words that are either speeding-related or speeding-unrelated, and words that are either synonymous with “good” or with “bad”, and must make one of two responses for each of these 4 types of words. For the “hypothetically compatible” stage speeding-related word share a response key with bad/negative words and speeding-unrelated words share a response key with good/positive words. For the “hypothetically non-compatible” stage this pairing is reversed. Participants should find the compatible stage easier than the non-compatible stage, and so performance should be faster.

The IAT effect is defined as the difference in mean response time for the non-compatible minus compatible stage. Thus, a positive IAT effect in the present study would indicate a negative attitude toward speeding or a positive attitude toward not-speeding.

The present research aims to develop an IAT to measure attitudes to speeding, and to test its predictive validity (against simulated driving behaviour, as well as self-reported measures of variables theoretically related to attitudes) and convergent validity (against self-reported attitudes).

Forty-five licensed drivers (42.2% female, mean age of 20-25 years) completed a questionnaire that assessed self-reported attitudes to speeding, social norms regarding speeding, perceived appropriateness of speed limits, perceived crash risk of speeding, speeding-related illusory invulnerability, speeding behaviour, number of speeding infringements, and number of speed-related crashes. Participants then completed two simulator drives designed to assess speeding in several speed limit zones. Finally, participants completed the speed-related IAT, half with compatible-before-incompatible combinations and half with incompatible-before-compatible combinations.

Consistent with previous research, the IAT effect was significantly greater when hypothetically compatible response combinations preceded non-compatible combinations, than when non-compatible combinations

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were presented first. The IAT effect was significantly greater than zero for both compatibility-order groups. These findings suggest that the IAT operated as expected in measuring implicit attitudes to speeding, and that attitudes toward speeding are negative.

Observed IAT results were generally consistent with results derived from the driving and self-report measures.

The IAT effect correlated significantly and negatively with percentage of recordings in excess of the speed limit in the 70km/hr and 80km/hr zones, and mean driving speed in the 80km/hr zone. A higher IAT effect was associated with the belief that speed limits are too high, a higher perceived risk of being caught when speeding, lower illusory invulnerability, and lower self-reported speeding. Means for all eight self-report measures of attitudes toward speeding indicate negative attitudes toward speeding, and several of these explicit attitude measures demonstrated significant positive correlations with the IAT effect.

The speed-related IAT appeared to be a valid measure of attitudes to speeding.

*Keywords – attitudes to speeding, implicit attitudes test, risky driving*

**References**

Abstract

Many virtual reality experimentations [1] pointed out that the risk accepted by drivers crucially depends on driver’s workload and traffic interferences.

Even if rear end collision represents the most frequent typology of road accidents on divided highway, traffic has not enough been taken into account in the road project. This is the consequence of the approach based on traditional standards that neglects human factors and driver’s behaviour.

Therefore this study has analysed the risk of rear end collision with a virtual reality experimentation whose main objective is to verify the variability of probability and severity in function of different traffic flow densities.

Particularly five traffic scenarios representing different levels of service according to the Highway Capacity Manual [2] have been developed under a virtual reality environment. Twenty subjects have been selected for the experiments (the average length of each scenario was five km). During simulation kinematic (longitudinal and transversal velocities, vehicle position on the road, trajectory, local curvatures of the trajectories, etc.) and dynamic (longitudinal and transversal accelerations, braking forces, centripetal forces, etc.) parameters are recorded with a spatial step of 10 meters (about 0.3 seconds) [3,4]. Moreover the time/space distances between the driver’s car and the other vehicles have been recorded.

Output post-processing has provided interesting results for the evaluation of the variability of subjective risk accepted by the driver in function of the level of service. The objective risk, computed as the product of probability and severity, has been evaluated for each scenario as well.

In conclusion an effective reduction in the number of road accidents could be reached only if the existing road infrastructures will be adapted to the drivers’ expectations under current traffic flows.

Keywords – rear end collision risk, driver’s behavior, driving simulation, level of service

References


Feasibility of automated speed enforcement on freeways in the US: the Scottsdale, Arizona experience

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Abstract
Automated speed enforcement programs (ASEPs) have been employed and evaluated at intersections and non-freeways in the US [1; 2]. There is considerable international experience with ASEPs on freeways [3; 4; 5]; however, fixed ASEPs on high-speed limited access roads are new to the US. In January, 2006, the City of Scottsdale in the state of Arizona implemented the first fixed-installation speed-enforcement demonstration program on a freeway.

The program was implemented on a 10 km portion of the 101 freeway that traverses the City of Scottsdale. The program was highly political, involved public officials at the highest levels, and received a large amount of media attention before, during, and after the program.

After a six month demonstration program followed by a technical evaluation (presented in this paper), the Scottsdale City Council voted to continue the program, the Governor of Arizona endorsed a statewide program, and the program was reinstated in early 2007 (City of Scottsdale). Efforts are ongoing to expand the program statewide.

This paper presents a comprehensive description of the program and its impacts. We present the program details, followed by the analytical results of a before-after (BA) analyses of the impact on safety (including crash costs and severity levels), on travel speeds, on travel times, on public perception, and on finances.

Of technical interest are the challenges in assembling the data necessary to evaluate the program, the evaluation methodology shortcomings (simple BA with correction for exposure, BA with comparison group, and Empirical Bayes’ BA with regression to the mean correction), the calculation of injury and crash costs, and the computation of travel time impacts.

The automated speed enforcement program and its effect on the safety of Arizona freeways have the potential to impact similar programs considered throughout the US.

The program has generated considerable state-wide and national interest, and has influenced the future potential of similar US programs.

The potential evolution of automated enforcement as a safety countermeasure on US freeways is discussed in closing.

Keywords – automated enforcement, speed, motor vehicle crashes
References


Modelling of Variable Message Signs
for driving simulation

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Abstract

Variable Message Signs (VMS) are dynamic items for traffic signalling and information which started to be widely introduced in the last years in the road infrastructures of the Spanish territory and other European countries. Their main purpose is to control traffic and adjust it to changes or incidents.

They are basically used to inform drivers about any event or incident interesting for road safety or traffic fluency like traffic density, nearby car accidents, closed roads or streets, adverse atmospheric conditions, etc. Furthermore, they are frequently used to remind drivers of important traffic rules in certain circumstances.

The current paper expounds the development of an architecture to define and model the 3-D texts and graphics that are visualized on the VMS. The generated models have been included in a driving simulator that was developed by the Institute of Traffic and Road Safety of the University of Valencia (INTRAS) after several years of collaboration among professionals of different areas like Computer Science, Psychology or Physics.

The motivation to incorporate VMS into the simulator is not only reduced to the fact that they are items of the traffic environment; there is also a great interest in the analysis and the evaluation of different aspects of them (legibility, understanding, efficiency, visibility, etc).

It has been some time since driving simulation has become an extremely useful tool to experiment with the purpose of analysing and evaluating different traffic and road safety characteristics [1]. In this sense, it offers a great help in many of the most relevant road safety areas like infrastructure analysis [2; 3], driver evaluation [4], training [5], etc. Furthermore, the use of simulation gives outstanding advantages compared with on-road experimentation ones.

These advantages are summed up to the possibility of analysing the VMS features and their influence on driving in a quicker and more economic way.

The INTRAS driving simulator is a high-performance system composed of a widely sensorised real vehicle that makes possible normal driving by means of its controls and a communication card that receives the information from each sensor; an immersive projection system consisting of a curve screen or three flat screens that cover more than 120 degrees of field of view and three high quality projectors with 1000 lumens; a graphic workstation able to generate all the images needed to represent the driving simulation scenes in real-time; and an advanced sound system managed by a PC running under Windows and composed of four loudspeakers and one subwoofer.
The implementation of the simulator software is done in C++ language and using the OpenGL Performer graphic library from Silicon Graphics. This library includes several kinds of classes to create and manage 3D objects, some of them are used to build and represent the characters and graphics that can be displayed in the Variable Message Signs panels inside the simulator.

Keywords – virtual reality, real-time driving simulation, road safety, VMS

References

In depth analysis of urban accidents involving motorcycle and moped riders in France, construction of prototypical accident scenarios and prospects for their prevention

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Abstract

Powered two-wheelers riders constitute, with pedestrians and cyclists, a category of road users who are particularly vulnerable in case of accident, given that the slightest collision exposes them to injury. In France, according to national accident statistics, accidents involving moped and motorcycle riders in towns account for 13.4 % and 12.4 %, respectively, of all injury accidents recorded [1].

Moreover, in urban areas where, in 2005, 69.4 % of all accidents recorded occurred, powered two-wheelers riders account for 31.7 % of traffic fatalities and 36.1 % of traffic injuries [2].

This extra risk is particularly marked in large cities. For example, in the city of Paris in 2005, powered two-wheelers accounted for less than 3 % of all travel but were involved in 60 % of traffic injury accidents [3]. The growth in the use of powered two-wheelers in towns and the over-involvement of this category of users in injury accidents demonstrate the need for a better understanding of powered two-wheeler accident phenomena in order to develop countermeasures, notably through road engineering.

This research (carried out at the Department of Accident Mechanism Analysis of the French National Institute for Transport and Safety Research, INRETS) uses an in-depth, qualitative analysis of a representative sampling of 278 complete police reports on urban accidents involving at least one powered two-wheeler and the concentration of these accidents in prototypical accident scenarios.

The cases are first analyzed and then aggregated to constitute various groups of cases considered as homogeneous from the point of view of the accident process. Each group of cases is then used to elaborate a prototypical accident scenario, giving the main features of the accident processes corresponding to this group of cases (on the concept of prototypical accident scenario, we refer to the reference [4]).

Twenty-five prototypical accident scenarios were drawn up and were used to demonstrate the influence of certain engineering choices in the production of accidents among this category of users. Then, a second representative sampling of 100 police reports (independent from the first sampling) were used in order to evaluate the representativity of these accident scenarios.

Possibilities for engineering countermeasures based on these prototypical scenarios are discussed with reference to the international scientific literature.

Keywords – motorcycle, moped, traffic accident, accident scenario, prevention
References

Modeling the crash frequency on streets with two-way left-turn lanes

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Abstract

A two-way left-turn lane (TWLTL) is a lane in the centre of a road that is designed for left-turn movements by both directions of traffic. It is commonly used as a median treatment on urban or suburban multilane roadways in the United States. By decreasing the conflicts between through- and mid-block left-turning traffic, it was believed that TWLTL could solve some safety and operational problems on urban roadways with high access density.

Even though the use of TWLTLs was originally envisioned to improve safety on urban/suburban multilane highways, recent practices in Florida have shown that a number of crashes reported are related to TWLTLs, and the use of TWLTLs might not provide the safety benefits once believed \([1; 2; 3]\).

Until recently, the safety effects of TWLTLs have not been carefully studied and little documentation is available concerning the safety performance of TWLTLs. The object of this study is to develop a crash prediction model to estimate the expected number of crashes on TWLTLs. The crash database for analysis was extracted from the Florida Traffic Crash Database based on the TWLTL section list provided by FDOT and combined with some traffic characteristics.

The database created in this study consisted of totally 1688 sample sections within a three-year period from 1996 to 1998. Based on the crash database, distribution fittings for Poisson, Negative Binomial and Lognormal regression were conducted for average number of crashes.

According to the results, statistical crash predictive model was developed to estimate the average number of crashes. Negative Binomial regression was applied with four variables, ADT, access density, posted speed and number of lanes for the TWLTL sections. The regression parameters were estimated by using maximum likelihood method with statistical software. The findings of the analysis indicated that all of the variables adopted in the predictive model significantly affect the occurrence of crashes. And the average number of crashes increases with the increase of ADT, access density and number of lanes, while with the decrease of posted speed.

Keywords – crash, two-way left-turn lanes, poisson model, negative binomial model, access management
References

Road accidents in one local health unit of Rome: first results of an integrated surveillance system police – medical data

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Abstract

Road traffic injuries (RTI) are an important public health problem [1]. Official surveillance based on police reports and managed by the National Institute of Statistics in 2004, reports for Italy about 6000 deaths and 320,000 RTIs [2]. International studies on the comparison between police and medical data showed that the two sources are not exhaustive, and the integration between the two, is able to describe RTIs [3; 4]. In Italy few local experiences carried out studies on the integration between two sources [5].

Aim of this study was to implement an experimental integrated surveillance for RTIs, between police and medical data in Local Health Unit (LHU) RMB in Rome, (630,000 inhabitants).

Data sources used were:

- Police database collects RTI reports (year 2003);
- Emergency Information System (EIS) collects all the admissions to the emergency departments (ED) in Lazio region (year 2003);
- Hospital Discharge Registry (HD) collects all the hospital discharges occurred in the Lazio Region (year 2003-04);
- Mortality Registry (MR) collects all the certificates of death occurred in Lazio Region (year 2003-04).

Experimental surveillance based on the integration between medical data (admissions to emergency department, hospital admissions and certificates of death) with police data through deterministic record linkage was performed.

The number of RT crashes, ED visits, hospital admissions and fatalities have been estimated. The nature of the injury and body region involved have been estimated. Factor associated with hospitalization were evaluated through logistic regression models.

RT crashes with at least one injured were noticed was 2890. About 75% of crashes occurred in good weather conditions, whereas only 8% during rainy days. Two peaks in the hour of accident were observed, at 9 a.m. and 6 p.m. due to heavy traffic density.
The number of injured persons was 4571 and 75% of whom was admitted to the ED. Out of the ED patients, 65.5% were males, 61.8% were young (<34 years of age). Sixteen percent (563 cases) reported hospitalization after the ED visit, while 44 deaths were noticed, in most cases in young males. Spine and back (24.4%) and lower extremities (19.0%) were the body regions mostly involved. More than one third of injuries resulted in contusion/superficial, while considerable was the percentage of fractures (11.8%). The most important risk factors associated with hospitalization was represented by the frontal crash; lateral crash vs. frontal crash (OR 0.51 CI 95% 0.31-0.84), collision vs. frontal crash (OR 0.52 CI 95% 0.32-0.86). Higher risk was observed for two-wheeled users than car ones; in particular use of motorbike had a high risk of hospitalization (OR 1.38 CI 95% 1.01-1.87).

This study showed the feasibility of an integrated RTI surveillance. Future efforts will be towards the construction maps of the spatial density of RTIs, which consider the severity of injuries, in order to give an instrument able to find the most risky points, which needs priority interventions. This systems could represent a model for the other LHU of Rome and Lazio region.

Keywords – road accidents, injuries, surveillance, record linkage

References
Safe spacing between unsignalized intersections on arterial highway

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Abstract
There are several ways to approach the issue of unsignalized intersection spacing including safety, stopping sight distance, intersection sight distance, functional area, right-turn conflict overlap, influence distance and egress capacity [1].

For the determination of safe unsignalized intersection spacing, the existing methods mainly use the statistical analyses based on the accidents indices. More than 40 years of accident analyses have found that the accident rates-expressed as accidents per million vehicle miles of travel—increase as the number of access points per mile increases [1; 2].

It’s well known that obvious positive relativity exists between traffic conflicts and traffic accidents [3]. Thus, some researchers use traffic conflict technique as surrogate safety measure to illustrate traffic safety problems. In this paper, traffic conflict technique is adopted to determine the safe unsignalized intersection spacing.

Regarding bidirectional four-lane arterial highway as research object, the relationship between intersection spacing and traffic safety is analyzed using traffic conflicts from the microscopic view based on the field data and simulation results by VISSIM.

The driving behavior and relevant traffic conflict types influenced by intersection spacing are analyzed firstly, thereby the safety degree of each link segment is illustrated regarding the TTC (time to collision) as surrogate safety measure which can determine the potential conflict types and severity degree[4].

The distribution of traffic conflicts number on the link should accord with the trend of “descending-calm-ascending” theoretically.

The distribution trend of traffic conflict on the link is analyzed under the given traffic circumstance and various spacing criterion, thereby the spacing model of safety is presented which is based on the surrogate safety indices (TTC). Moreover, the routine evaluation indices are taken into account, such as stopping sight distance, intersection distance, and etc. Thereby, the safe spacing between unsignalized intersections is determined.

Finally, the contrast of operation efficiency before and after spacing modification is analyzed using average delay and average running speed indices, and the results show that the operation efficiency is better under safe spacing criterion.

Keywords – highway, unsignalized intersection, safe spacing, traffic conflict, traffic simulation
References

Study of passing gap acceptance behavior using a driving simulator

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Abstract
This paper presents research to evaluate drivers' passing maneuvers on two-lane rural roads using data collected with an interactive driving simulator (STISIM) in a laboratory environment. In addition to the observations of driving behavior obtained in the simulator experiments, drivers' socioeconomic characteristics and indicators of their driving style were collected using self-reported questionnaires.

Participants responded to a questionnaire which collected socio-demographic information, such as age, gender, marital status, education and income.

The questionnaire also included the multidimensional driving style inventory scale (Taubman-Ben-Ari et al. 2004), which describes four different driving styles: anxious, angry and hostile, reckless and careless, patient and careful.

The same participants were asked to drive a 9.5 km two-lane rural road section with no intersections. In the simulation scenario, all vehicles going in the same direction as the subject were traveling at 60 km/hr, whereas the posted speed limit was 90 km/hr. All vehicles going in the opposite direction were traveling at 70 km/hr. Headways between vehicles in the opposing direction were drawn from a truncated negative exponential distribution with bounds of 9 and 23 seconds.

The headway distributions, as well as other variables selected for the experiments, were based on values obtained for typical two-lane highways in Israel.

The average travel time needed to complete the simulator experiment was 8.5 minutes. Each participant was given between 5 and 10 minutes to become familiar with the simulator. The positions and speeds of the subject vehicle and the other simulated vehicles were recorded at a resolution of 0.1 seconds.

The data collected in the experiment was used to develop a model that explains drivers' passing decisions. The results indicate that the positions and speeds of the subject vehicle with relations to the vehicle being passed and the nearest vehicle in the opposite direction are the most important factors affecting passing behavior. In addition, drivers' impatience as well as their socio-demographic characteristics and driving styles also affect passing decisions.

Keywords - gap acceptance, driving style, driving simulator, two-lane highways
References

Sample-based Bayesian reconstruction of road accidents

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Abstract
As commonly practiced, accident reconstruction often involves combining physical structural equations, measurements made at the accident scene or on the involved vehicles, and prior knowledge concerning plausible values of some unmeasured variables, in order to estimate the values taken on by other unmeasured variables. For example, consider the critical speed formula used to estimate speed from a measurement of the radius of a yaw-mark:

\[ V = (R\mu g)^{1/2} \]

where
\( R \) = measured yawmark radius
\( V \) = vehicle speed
\( \mu \) = friction coefficient
\( g \) = gravitational acceleration (~9.8 meters/sec\(^2\)).

A measured radius of 55 meters, together with a prior estimate of 0.8 for the friction coefficient, would give an estimated speed at the start of the yawmark of about 20.8 meters/second. In a Bayesian reconstruction, the yawmark radius would be assumed to be subject to measurement error, the point value for the friction coefficient would be replaced by an informative prior probability distribution, and Bayes Theorem would be used to compute the posterior probability distribution for the vehicle’s speed. An overview of the Bayesian approach to accident reconstruction can be found in [2]. In sample-based Bayesian reconstruction, the data from the accident in question is supplemented by measurements from field tests, in effect giving an empirical basis to some of the prior distributions. For estimating speed from yawmark radius, we begin with the structural equation

\[ R = (V^2/\mu g) + e \]

where \( e \) is measurement error, and then using a set of measured speeds and yawmarks reported in [5] estimate parameters for the distribution of friction coefficients. This distribution is then used as an informative prior for estimating speed when only the measured yawmark radius is available. The Bayes estimates are actually computed by treating the reconstruction case as exchangeable with the field measurements, but with missing data, and a joint estimation of the case’s friction term and speed are computed using the Markov Chain Monte Carlo program WinBUGS [6]. We have also applied this approach to estimating speed from crush measurements in pole crashes, using the data and model described by Nystrom and Kost [4].

An application of the method to estimating vehicle speed from pedestrian throw distance, using the throw distance model described in [1], using field data tabulated in [3], is in progress.

Keywords – accident reconstruction, Bayesian analysis, Markov chain Monte Carlo
References

Safety and environmental performances of a photocatalytic innovative pavement

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Abstract

The technology involved within the chemical phenomenon of photocatalysis represents an innovative mean for the control of pollutants concentration in atmosphere. Photocatalytic materials, treated with titanium dioxide, speed up natural reactions of oxidations, favouring the degradation of pollutants into inert substances.

In the light of latest scientific confirmations of air pollutants damaging power to both health and environment, the design of a photocatalytic road pavement is an opportunity that can’t be failed any more.

The design of an effective photocatalytic pavement presents a twofold problem, concerning on one side the setting up of an appropriate method of application of the photocatalyst on the surface, on the other the achievement of friction performance usually required to a traditional wearing course.

In this paper the Authors present an analysis concerning a micro photocatalytic layer, made up with a bituminous open grade course partly filled up with a special photocatalytic mortar. The analysis aimed at evaluating the effectiveness of the depollutant action due to the photocatalytic mortar as well as the equality of the correspondence of the surface features to a suitable level. The micro layer actually has to guarantee both a significant depollutant power and suitable surface features, in accordance with friction and macro texture requirements, able to guarantee road users safety.

The experimental investigation was aimed at defining the most appropriate characteristics of the asphalt concrete layer to guarantee the best interaction with the cemenitious mortar, and at analysing the micro photocatalytic layer considering both its depollutant power and its friction features.

The surface features were tested through measurement of friction and macro texture and then compared with the characteristics of a traditional asphalt concrete layer. Methods of friction improvement, previously tested for a similar photocatalytic pavement by the Authors, were also implemented and adapted to this pavement. Results were evaluated.

The effectiveness of the photocatalytic pavement relating to its depollutant power was tested throughout laboratory tests: samples of pavement of different ages were extracted from real scale applications and tested measuring the reduction of pollutants’ concentrations due to the action of the photocatalyst present on the samples’ surface.

Keywords – pavement, photocatalysis, air pollution, adherence
References

Investigation of road accidents with in-depth analysis: 
an experience from Thailand case studies

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Abstract

Road accidents are regarded one of crucial causes of premature deaths and long term disabilities of economically active segment of the population in the developing countries. Particularly, the innocent young population is decimated due to the unexpected consequences of collisions when statistics of 50 percent of total fatalities comprise working adults age group (25-59 years) followed by 15-24 age group with 28.73 percent [1].

On an average, more than 12,000 people succumb to deaths with associated accident cost comprising about 3.4 percent of Gross National Product (GNP) [1] annually indicating a general picture of road accident situation in Thailand. Recognizing the urgent need of conducting research to provide the knowledgebase to understand the road accident problem in Thailand, Thailand Accident Research Center (TARC) was established. Since its inception, TARC research team investigated accident cases and motivated to identify the possible factors leading to collisions with proper in-depth analysis from available information from at-scene investigation, assessment of crash involved vehicles and injured occupants of the vehicles. With proper information of road accidents from news agency, TARC investigation team attempted to investigate the accident cases directly with specified investigation forms to capture the necessary information from crash scene (i.e. road and environment), crash involved vehicles and injured occupants. In addition, statements of drivers, passengers, eye witnesses and any physical evidence on road surface, for instance, tire marks, debris, blood strains and oil spatter, were meticulously investigated and documented for further analysis that could be critical for both event and mathematical analysis applying accident reconstruction approach.

With a view to describe the events of crash from the available information through accident reconstruction [2] is one of the objectives of in-depth analysis of investigated cases under TARC. Moreover, the simulation of accident cases based on the in-depth analysis is also carried out of interesting cases with reconstruction software.

This paper investigates the possible factors considering road-vehicle and driver components in road safety. The accident cases were systematically investigated and analyzed following the scientific approach to determine crash parameters to describe the events leading to collisions.

This paper highlights collisions between two trucks at intersection, bus and pickup on straight highway, and passenger car and gantry post with in-depth analysis through accident reconstruction approach and simulated animations by PC-Crash software.
Furthermore, conventional hand calculation was performed based on the physical evidence found at the crash scene after the direct investigation to the accident cases to determine the travelling, pre-impact and post-impact speed of the involved vehicles.

It is believed that this type of in-depth research work in road safety is quite innovative and the first of its kind in Thailand as well as in other developing countries in Asian region. Considering the factors in road crashes, road-environment and vehicles are not of the same standard as developed countries in developing countries perspective [3] which is highlighted in this research work.

So the findings of the investigated cases will foster the better understanding on road accidents as ‘chain of events’.

Keywords – investigation, reconstruction, in-depth analysis, contributing factors, simulation

References

3. Islam, M.B., and Tanaboriboon, Y., “Crash Investigation and Reconstruction...The New Experience in Developing Countries: Thailand Case Study”, In proceedings of the 13th International Conference on Road Safety on Four Continents (CD-Rom), Warsaw, Poland, October 2005. pp 874-884.
Use of mobile phone while driving among car drivers in Malaysia

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Abstract

The car is the second most (43.7%) common mode of transportation in Malaysia, next to motorcycle. Of 6,200 road fatalities in year 2005, car drivers made up of 11.6% (719) of the deaths and 9.3% (3,806) of casualties. Car passenger fatalities take up another 8.5% (525) of the total fatalities. Thus the safety of the car driver and its occupants in a matter to be addressed towards addressing the road traffic accidents in the country.

One of the possible reasons for high number of traffic accidents occurrence is due to less concentration on the road by the driver while driving. Among the activities that could divert the concentration and capacity of wheel control while driving is by engaging in another activity such as using mobile phone while driving which is getting very high momentum in the country [1; 2]. Total number of summons issue to improper usage of mobile phone while driving in Malaysia increased from 35,069 cases in year 2001 to 41,257 in year 2003. The increasing number of summons issued to the usage of the mobile phone among driver in Malaysia strongly indicates a need for a study on the mobile phone usage while driving. Therefore this study aims to investigate the association between compliance on proper usage of mobile phone and the driver’s characteristics.

A questionnaire study was carried out in the state of Selangor, Malaysia on compliance behaviour of drivers in relation to the proper usage of mobile phone from June to August 2004. The data collection was done by observation whether the drivers complied with the proper usage of mobile phone before being approached to participate in the questionnaire research study. A minimum sample size of 218 respondents was needed for the study and finally 220 were interviewed in four study stations. The data were later analysed using chi-square test with significance level set at 0.05 level. Sufficient statistical power was maintained in each cells tested for bivariate analysis.

The study showed 46.8% of drivers were using mobile phone while driving and among them 65% were using it properly (with a hands-free kit). Seven factors were tested against the proper usage of mobile phone and three factors were found significantly associated. They are: drivers who works in a less mobile environment (such as working within an office premises and housewives), drivers who were involved in long (above 30km) travel distance and the driver who agrees that they are distracted while driving with a mobile phone at hand are more likely to comply with the mobile phone usage while driving regulation (using with a hands-
free kit). The other four factors, which were found insignificant, are the driver’s age, gender, education level and the location of travel.

Therefore road safety programs should be focused more on drivers who are much more mobile in the working place such as businessman and student, drivers who travel in a short distance trip (30km and below) and drivers who feel conversation while driving is not a distraction.

**Keywords** – road crashes, car drivers, mobile phone usage, compliance

**References**

Pedestrian-vehicle interaction and conflicts under various crosswalk treatments

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Abstract
To improve pedestrian safety in campus crosswalks, some innovative treatments such as in-street pedestrian crossing sign and in-roadway warning lights were implemented. It was found from field observations that these treatments can increase the yield rate for pedestrians and reduce the number of conflicts between pedestrians and vehicles.

However, the causes of the conflicts, either by pedestrian or by drivers, as well as the changes in the conflict type due to the treatment is not known.

The objectives of this paper are to determine the “risk factors” that contribute to the frequency and type of conflicts at crosswalks, and to establish the relationship between the conflict risk and the risk factors.
A total of 24 locations with various crosswalk treatments in the campus town of the University of Illinois at Urbana-Champaign were selected for data collection. The crossing treatments include unmarked crosswalk, marked crosswalk, in-street pedestrian sign, pedestrian sign on curb, and crosswalk with in-roadway warning lights.

To determine the risk factors, first, the types and causes of the pedestrian-vehicle conflicts corresponding to pedestrian and vehicle volume were analyzed with short time intervals (10 minute) at each location; and then, the locations with different crosswalk treatments were compared in terms conflict frequency, type, and cause.

In addition, the looking behaviour of pedestrians was also analyzed. It was found that the number of conflicts depends on the combination of pedestrian and vehicle volumes, and the conflict types and causes are related to the traffic component and geometry in the crosswalk. For those locations with innovative treatments, the change in the yield rate was significant, but the change in conflict rate was not significant if the combination of traffic volumes is greater than a certain threshold. A change in the pedestrian looking behaviour was also found at some locations.

Based on the analysis of the risk factors, a risk prediction model for estimating the conflicts in a crosswalk is presented. This model can be further used in a traffic simulation environment to evaluate the risk of campus crosswalks under a variety of volumes, treatments and geometric conditions.

Keywords – conflict analysis, pedestrian vehicle interaction, crosswalk treatment, in-street pedestrian crossing signs, risk factors
References

The research of vehicle detectors serve for road network safety operation

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Abstract
The emplaced density of vehicle detectors plays an important role for managers to master the traffic conditions and to know or evaluate the safety of road network.

This paper mainly takes static safety evaluation and dynamic safety evaluation of road network into account, and focus on how to emplace vehicle detectors to satisfy the demand of these two evaluation methods. According to the method of static safety evaluation, the whole road network could be divided into many individual segments by its safety grade.

Each segment will be considered as an element for emplacing vehicle detectors. Otherwise, in method of dynamic safety evaluation, the real-time vehicle density and velocity in a segment are needed. Therefore simulation tests are used to find the impact of density of vehicle detectors on the results of dynamic safety evaluation in each element.

At last, the method of how to locate vehicle detectors served for road network safety operation is found out by satisfying the needs of dynamic safety evaluation.

The conclusions of this paper could improve the use efficiency of vehicle detectors and safety management level of road networks.

Keywords – vehicle detector, static safety evaluation, dynamic safety evaluation
Locating in-car controls: predicting the effects of varying design layouts

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Abstract

As cars incorporate more functionality (e.g. navigation, MP3 players, advanced climate), it is increasingly important for automobile manufacturers and suppliers to understand the ease with which drivers are able to locate secondary controls when presented in varying layouts. Distraction is a well-established cause of crashes within existing cars and any technology with the potential to add to the problem must be carefully designed. Design tools which can aid in predicting the ease of location early in the development process with basic prototypes will be especially valuable [1; 2].

This paper describes two studies which aimed to understand the relative importance of different key design parameters on the location of in-car controls.

In study 1, 18 participants followed a lead vehicle within a fixed-base driving simulator and at specific points were asked to find and then select a specific control from an array of controls on an in-car touchscreen. The control layouts varied according to: the number of controls (9, 16 or 25 controls); control size (14x10mm; 20x13mm; 28x20mm); and control spacing (5mm; 10mm; 20mm). Results indicated that the number of controls was the dominant factor, having a clear relationship with task times, visual demand and subjective ratings.

In study 2, 20 participants carried out a similar driving task within the simulator, but in this case the layouts for controls varied according to: total cluster size (4, 6, 9 or 12 controls); and arrangement (how many controls in the horizontal versus the vertical plane). For this study, there was evidence that the vertical dimension had a clear relationship with task times, visual demand and subjective ratings. In other words, for the same total number of controls, drivers would take longer to find controls, make more glances away from the road and rate the task as more difficult, when the controls were laid out predominately in the vertical, rather than horizontal dimension.

The results of the two studies have been used to develop preliminary equations which can enable designers to predict task performance and ratings according to different control design layouts.

Future work is aiming to incorporate the results of this research into the well-known Keystroke Level Model (KLM). KLM is a modelling method used in Human-Computer Interaction (HCI) which has been shown to be a valid means of predicting drivers’ performance (task times and visual demand) with alternative in-car user-interfaces (2).

Keywords – human-machine interface, control design, modelling task performance
References


Modeling of human spine and biomechanical analysis of correlations between human body movement and internal forces

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Abstract
Neck injury can occur in many types of accidents. Traffic, sport accidents and jumping into shallow water are one of the most frequent reasons of serious human cervical spine injuries. These accidents can cause injuries that range from mild cases of neck pain, to injuries that can cause paralysis of the rest of the body below the level of injury or even death.

The most serious cases of human spine damage are connected with penetration of broken bones into spinal cord canal. In most cases accidents of that kind happen to young people, who in these cases are eliminated from healthy community [3].

Neck injury mechanism is especially connected with a head motion. Improvement of knowledge about correlation between crash dynamics, human body behaviour and internal cervical phenomena could contribute to the defence against dangerous traumas. The best information about above mentioned correlation could be obtained during test on volunteers but experimenting on people is usually impossible because of its dangerous character. Researches on volunteers could be conducted only in safe velocity or on animals, dummies and cadavers. Another way to study the behaviour of the human body and internal interactions during car crashes is the mathematical modelling, with the use of latest numerical methods. This is proposal a non-invasive method, which great advantage is unlimited repetition of numerical simulations for different assumptions [1; 2].

Modelling researches concerning neck injury mechanisms acting during road accidents and their consequences for human life are presented in this paper.

The investigations mainly focus on flexion and extension injuries mechanisms. In order to analyse correlation between head movement and physical phenomena in the cervical spine, two dynamical non-linear models were created.

The first 2-dimensional model of driver was created for frontal and rear car accidents analysis.

The second 3-dimensional model was created in order to analyse muscle influence on spine during situations corresponding to front collisions.

The models allow to analyse movement in sagittal plane. The first two-dimensional model was created using professional system WorkingModel 2D and the second spatial model (as an author program) formed in MatLab system.
Results of numerical simulations allowed analysing correlations between accident conditions, human body especially head behaviour and internal forces which could cause spine injuries.

**Keywords** – neck injuries, road accidents, modelling, numerical simulations

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**References**

Didactic and organisational pre-requisites for a successful training on simulators

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Abstract

German Road Safety Council DVR and the German work accident insurers (HVBG) have been operating a stationary training simulator to prevent traffic accidents since 2005. The computer based simulator allows mounting either a passenger car driver's cab or that of a van. The driver's view is of 210 degrees horizontal toward the direction of motion, and its electromechanical motion system can be moved into six directions. The driving dynamics corresponds to that of a passenger car or that of a van, according to the driver's cab chosen.

Evaluation 1

A first evaluation in 2005 exclusively dealt with the compatibility and the technical functionality of the simulator. The test persons did two training units of 3 resp. 7 minutes of duration. The evaluation result was not satisfactory. There was a break-up rate of nearly 20 per cent.

The high discontinuation rates were not accompanied by a higher rate of simulator-induced disease symptoms. Nor could disturbances in well-being or information on the psycho-physical constitution of the test persons explain conclusively the higher break-up rates.

Evaluation 2

Following this, DVR decided to start a follow-up examination in order to obtain a clear idea of the typical conditions for a seminar. The intention was also to reach a higher ecological validity. Therefore, full-day seminars including the full training range and the same driving tasks were conducted. From a technical point of view, the simulator remained unchanged, and the movement algorithm as well as the parameters of the movement system remained the same.

Two driving tasks were conceived. The three minute initial training included only few curves and no additional incidents. The seven minute training included driving through curves, turning to the left or the right, braking and overtaking, and additional events such as pedestrians crossing the road, children playing at the roadside, side-wind effects etc.

The repetition of the measurement design was conceived with four measuring units. The test persons were interviewed in writing before and after the first training, and also before and after the second training. Fig. 1 gives an overview of the data collected at each measuring time.

The training units were embedded in a one-day seminar concept which included the use of CBT programmes as well as classical training units.
The main study results were:
The break-up rate could be reduced to under eight per cent.

No time-shifted increase of simulator-induced disease symptoms between training 1 and 2 could be observed.

On an average, none of the simulator characteristics was considered "bad" or "extremely bad".

Nearly half of the simulator characteristics collected after the first training unit, and over half of them collected after the second unit were considered "good".

Persons attending the training on the simulator get accustomed to driving on a simulator just like changing over to another vehicle.

Persons attending the seminar are curious to see what the next training unit will offer, and in their minds driving on the simulator is connected to an event that they look forward to.

Participants to whom driving a car means a lot of joy and fun have a more favourable opinion on certain simulator characteristics than other persons. For them it is easier to get accustomed to driving on a simulator. This study demonstrated that the driving simulator run by HVBG and DVR is an adequate learning tool among other media and is useful for carrying out traffic safety seminars. The simulator is particularly advantageous for seminars which are conceptualized in such a way that "new media" (new tools) are applied during the seminar.
Experimental analysis of driver’s reaction time

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Abstract

Road safety is an issue crucially affected by human factors. This should suggest to engineers that driver’s behaviour has to be considered more in depth. Driver’s reaction time deeply impacts on the safety of driver manoeuvres. Psychological sciences approach is not properly consistent to objectives of road engineering. This is why the results can not be extended immediately to road engineering. Furthermore the technical regulations in different countries often disagree.

This paper presents an experimental investigation performed using an advanced interactive driving simulator whose main objective is to analyse the variation of driver’s reaction time under different traffic conditions. Particularly twenty young adults participated in the study driving five times the same scenario, increasing every time the traffic flow.

All the risky drivers behaviours (defined as a sudden braking of the driver to avoid an imminent collision) occurred during the simulations were recorded and analysed. Each driver’s manoeuvre is the final driving consequence of a perception reaction mechanism. The authors refer to effective reaction time defined as the interval between the instant of perception and the instant in which the driver reaches the action’s aim (instant of the maximum deceleration in the braking phase). The effective reaction time is computed as the sum of a physiological reaction time, based on human behaviour, and a time that depends on brake pedal driver’s pressure and braking system characteristics.

The study analyses the variability of the reaction time to the traffic flow, average speed and driver’s local speed at the time of perception.

The outcomes have important influences on road design and traffic management in terms of safety with great impact to those design standards that depend on reaction time.

Keywords – reaction time, speed, virtual reality, risky behavior, human factor

References

3. Törnros, J., 1995. Effect of driving speed on reaction time during motorway driving. Accident Analysis
Consistency of two - lane rural highway:
a new approach with environmental speed

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Abstract
In order to realize a safety road design, all the features and elements which influence vehicle operation (horizontal and vertical alignment, road section, side obstacles etc.), need to be related (consistency) to the vehicle speeds on the road. Specifically it has been shown that the accident rate directly depends on the variations of speed found in adjacent elements [1; 2].

For this reason, the most recent standards on the road design check on the operating speeds by imposing some limits on their variations among consecutive elements. In the literature different models are available to predict the operating speeds on two lane rural road; some models are exclusively based on the geometric characteristics of the element; others also keep in mind the approach speed to the same element; others introduce a relationship between the speed of the element and the overall characteristics of the road. In this last category there are models that characterize the road or part of it with a reference speed said “environmental” speed [3]. The environmental speed is defined as 85th percentile of the of the observed free speed distribution on the longer tangents or large radius curves on the section, at low traffic volumes. It depends on the location of the road in the territory (zones more or less urbanized), from the general topography conditions of the area, from the general standards of the road (horizontal and vertical alignment, cross section, pavements conditions, frequency of intersections or access points etc.).

Previous studies, carried out at the Department of Civil and Environmental Engineering of the University of Trieste, have shown that the environmental speed (for homogeneous section, not interested by intersections or access point) can be identified with a geometric parameter represented by the curvature change rate CCR [4].

In this paper we try to evaluate if the environmental speed, can represent also an indicator of the road safety, besides functionally characterizing a road section, besides improving the models of predict operating speeds. Various roads with similar functional characteristics (National roads of the region Friuli Venezia Giulia) are analyzed by selecting the homogeneous sections and the relative environmental speeds. An indicator of risk accident has also been associated to every section. According to own preliminary analysis a clear correlation between the accident rate and the change of the environmental speed along a section seem to emerge. This fact leads to innovative criterions of consistency of the roads. This could constitute an effective tool for the safety evaluations in the strategy for maintenance and rehabilitation of the existing roads.

Keywords – road safety, road consistency, operating speed, environmental speed, curvature change rate
References


User information and traffic management: how to tackle safety issues

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Abstract
The study that is described in this paper has been developed within the IN-SAFETY, a co-financed European project which aims to use intelligent, intuitive and cost-efficient combinations of new technologies (ADAS, IVIS), innovative infomobility concepts and traditional infrastructure best practice in order to enhance the forgiving and self-explanatory nature of roads.

Development of new simulation models (micro and macro) and risk analysis tools to estimate the safety of roads; development of training tools and curricula for road, TMC (Traffic Management Centre) and tunnel operators, is part of the project.

The emphasis of this report is about the improvement that can be obtained in safety using the Traffic macro models both in off-line situation as simulation tool for assessment and on-line as tool for supporting dynamic traffic management.

Basic idea is to introduce the “safety level” concept. The “safety-level” can be obtained with two methods: the first method is to use the graph of road network, used by the traffic models or by the navigation systems, in order to localize the accidents (Historic data) and use such statistics for defining the so called “black spots” taking into account also the gravity of the accidents. The second method can be obtained as a second step: after localising the accidents in one area it is possible to use the information that the models have in term of geometry of the road, speed, traffic flows etc. in order to understand which characteristics are mainly correlated with accidents. These correlations can be used in areas where the accidents are not localised and allow to define the “safety level” of the roads using the data models.

Once each link of the graph of the road network has been added with “Safety-level” indicator the traffic models can be used at three different levels:

- Level 1: informative (presentation to the driver of “safety level” of link of the network)
- Level 2: provide path information for “safe path” (maximize “safety level”) through navigation tools (on and off-board)
- Level 3: traffic management to define a reference “traffic flow distribution” which is “safer” (“town supervisor” approach)

The informative level means that the driver can be informed about the safety criticism (“safety-level”) of the road. The information can be given through different methods: RDS-TMC, VMS (Variable Message Sign) on the road, virtual message signs on the vehicle, etc.
The second level is based on the above information on “safety levels” of the roads and/or on the info about accidents present on the networks while the vehicle is moving. In this case a dynamic navigation system can provide, when requested by the driver, a route avoiding the accidents in the network and/or suggesting safer route taking into account not only the shortest or the faster route but also the safer route.

The level three requires to have a traffic control center. In this case it is possible to define the optimum distribution of traffic taking into account both the accidents on the road and also the “safety level” of the links together with the usual “generalised” cost of the network in terms of travel time, road charging etc. The on-line control strategies to be activated can take into account of this new reference equilibrium.

All the tests have been done using MT.MODEL, the MATRIX supervisor system and on-line data.

The methodologies and the needed upgrade of the macro-models (for instance an ad-hoc and innovative multi-class assignment model etc.) and navigation systems are described in the paper together with the results of the analysis and of the performed tests. First results of the application of methods for safety-level computation in the real case of the city of Turin are described together with some result on experiment concerning application of the different levels of use of models. Results of the time saved avoiding accidents and about the different routes selected are presented. During the project tests with real drivers who follow the different routes suggestions have been done.

**Keywords** – infomobility, multi-user safety-route optimisation, dynamic route guidance, black spot prevention, safety

**References**

Evaluation of a complex at-grade rail crossing design using a driver simulation: a case study

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Abstract
This paper deals with the unique and first time application in Canada of a driving simulator to assess a complex combined at-grade railroad and bus rapid transitway crossing design. The project involved the at-grade crossing of a major 4-lane divided arterial roadway in Ottawa, Canada by both a railway and transitway within a 30m envelope.

In an initial process, the proposed roadway design was reviewed in detail by the consulting team and City of Ottawa technical staff using the driving simulator to help visualize specific changes that led to a refined plan that was submitted for the more detailed driver behaviour testing. The purpose of this simulation was to optimize the positive guidance offered to drivers using the crossing.

We first provide an overview of the concerns associated with the proposed crossing design that lead to the decision to use a driving-simulator approach to its evaluation.

In the second section of the paper we discuss the data and information requirements necessary to construct the computer model for insertion into the driving simulator – and the particular challenges encountered in meeting these needs.

We then discuss the specifics of the driving simulator study. The proposed at-grade crossing design was evaluated by having 47 participants, stratified into the age groups of 18 to 24, 25 to 55, and 55 and older, drive the combined crossings in both directions. After and initial practice drive in the University of Calgary Driving Simulator (UCDS) the study participants then drove two 15 minute drives with the Fallowfield roadway embedded in routes that resembled the countryside in the area of the actual crossing in Ottawa. During these drives, participants encountered free flowing traffic in either direction through the grade crossing, a late light change to yellow, waiting for a train to pass through the entire warning and signal sequence, and a stalled truck between the rail and transit intersections.

A number of simulator measures were collected during participants’ drives, including: velocity; stopping accuracy; the probability of stopping at the crossing; and manoeuvre type in response to the stalled truck. A number of eye movement measures were also collected, including: the percent of drivers who detected the various signs and signals; the distance at which the first glance to a traffic sign or signal was made; the...
distance at which the last glance to signs and signals was made; and the total number of glances to signs and signals.

The participants were also interviewed about how well they understood the crossing elements, with a specific focus on the human factors methodology used to evaluate the performance of drivers within the proposed crossing environment.

The study was judged a significant success, and the output of the driving simulation analysis influenced a number of key features of the final design of the warning and signal systems for the combined at-grade crossing.

The paper concludes with a discussion of the advantages, limitations, and challenges associated with using a driver simulator approach to evaluating real-world road infrastructure and positive guidance design applications.

Keywords – railway crossing, positive guidance, driving simulation, eye movement, human factors
How does traffic density influence cyclist’s gap choices?

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Abstract

Bicycle crashes are among the most common causes of severe injury in childhood. Bicycle-motor vehicle collisions at intersections represent a particularly prevalent source of bicycling injuries \cite{5}. Despite growing international concern over promoting children's bicycling safety, the underlying causes of bicycle crashes remain poorly understood. Using an immersive, interactive bicycling simulator, we are conducting experiments to study how children and adults cope with the everyday challenges of negotiating traffic-filled roadways comparable to those they confront in the real environment.

A robust finding from our prior research on road-crossing behavior is that children choose the same size gaps as adults, but leave less headway when they start to cross \cite{4}. Consequently, child cyclists have far less time to spare when they clear the path of the oncoming car. This puts child cyclists at greater risk for a collision because they have less time available to recover from an error such as a foot slipping off the pedal.

In this paper, we report on an experiment examining how traffic density influences the choice of whether or not to cross a gap.

Subjects crossed a single stream of traffic at 12 intersections riding our bicycling simulator. On the first and last four intersections, the gaps between vehicles were randomly distributed between 1.5 and 5.0 s. On the middle four intersections, subjects encountered a series of uncrossable gaps before a crossable gap appeared. We hypothesized that children and adults would choose smaller gaps when forced to wait than when presented with a random assortment of gaps.

As in our earlier experiments, the results show that children and adults chose the same size gaps, but children ended up with less time to spare than adults when they cleared the path of the oncoming car. We also found that children (especially younger ones) made more motor errors during crossing than did adults. The fact that children made more errors during crossing is especially significant given that children had less time available for crossing than did adults, leaving children with a smaller margin for error.

Both children and adults were willing to accept much smaller gaps when they had to wait for a long time before a minimally acceptable gap appeared. This is consistent with recent work on sighted and blind pedestrians’ gap choices in high-density traffic \cite{2}. Similarly, studies have found that drivers who have long wait times tend to accept smaller gaps \cite{1; 3}. In addition, children and adults were more willing to accept tight gaps during the last four intersections than during the first four intersections.
We consider possible explanations for why the children and adults choose to cross smaller gaps in dense traffic and why the bias to accept smaller gaps persisted at subsequent intersections even when larger gaps were available.

Keywords – gap acceptance, road crossing, bicycling, traffic density, simulation

References

Advances in traffic monitoring technologies

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Abstract

Design of experimental applications of ITS monitoring devices on the national road network of Italy is presented. Both theoretical aspects of measuring traffic variables and technical requirements of devices are discussed.

In the last years, the fast development of Intelligent Transportation Systems (ITS) has made available many technologies collecting automatic traffic counts. Thanks to such systems it is now possible to accomplish traffic monitoring and surveillance more efficiently. In this regard, ANAS has developed the SMART project, a research program addressed to define monitoring devices technical requirements for both ITS and traffic census applications on the national road network.

The SMART Project was conceived to compare different traffic monitoring technologies in terms of reliability and accuracy in relationship with peculiar monitoring objectives.

The aim of the project is to identify a set of application fields in which the devices can be correctly used, depending on road category, required accuracy and environmental conditions for each monitoring goal. Several monitoring conditions were identified and for each of them a statistically significant sample size of measurements was collected.

An experimental site has been set up within the SMART Project where the following six different traffic technologies have been tested:

1. Inductive loops;
2. WIM sensors (Weight in Motion);
3. Active laser sensors;
4. Triple technology sensors;
5. Double technology sensors;
6. VIP sensors (Video Image Processors).

A one year survey has been carried out to assess technologies response to weather and mechanical solicitations. Vehicle counts and classification reference measures are obtained by manual control of recorded video images, allowing to check anomalous devices response to outer conditions or systems faults too.

Validation equipments adopted as reference system include: a continuous video surveillance system composed by two cameras, mounted on an overpass bridge, to record the traffic flowing on the road stretch where the sensors were installed, and a laser system based specifically devoted to check and validate the
devices under test. Speed data validation requires the reference system being able to measure speed in real traffic condition, with an accuracy higher than those declared by the manufacturers of the devices to be tested. To fulfill such a requirement was specifically designed. A matrix of infrared sensors and special reflecting tools (developed in order to separate single lane measurements) was used to implement automatic speed measurements and allow accurate measurements without road restraints.

A DGPS in-vehicle speed measurement equipment with high positioning accuracy was used to test and validate the reference system.

Preliminary results show that best performances are provided by the Double and Triple Technology devices, and by one type of WIM system.

Keywords – traffic monitoring technologies, reference systems, measurement accuracy

References

Developing HMI components for a driver assistance system for safe speed and safe distance

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Abstract
This paper is aimed to provide a detailed description of a pre-screening procedure that was followed with a number of candidate Human-Machine-Interaction (HMI) solutions in two different modes (visual and auditory) for the concepts of Safe Speed and Safe Distance (referred to as SASPENCE) of an Advanced Driver Assistance System (ADAS).

This testing procedure was carried out in two European countries, Sweden and Spain, in 2004. In each country, two groups (of about 30 drivers each of them selected randomly according to gender and age) participated in a two-phase test method. Eleven visual display alternatives for speed information and ten alternatives for distance warning as well as twelve auditory warning sounds were screened using a standard procedure and considering aspects such as comprehension, preferences and acceptance.

The aim of this activity was to select the best HMI alternatives for SASPENCE system to be further tested in subsequent driving simulator and field studies. Specifically, the testing procedure followed in Spain is the one that will be presented and described along this paper.

There is a well established relationship between the speed level and the number and severity of accidents [1]. Besides, too short car-following distances contribute to a large proportion of road accidents, from 13% in Europe to 28% in the USA and 33% in Australia. However, newly developed in-vehicle systems based on Information and Communication Technologies offer the possibility of supporting the driver to maintain safe speed and safe distance to the vehicle ahead. On an earlier research stage, a literature review revealed that, providing the driver with relevant, concise but comprehensive timely information is of paramount importance so that the driver has sufficient time for reading, understanding and reacting. Thus, the design of the HMI is of major importance for warning the driver in critical situations.

An established standard procedure, developed by the American National Standards Institute, was applied [2], where twelve different alternative candidate auditory sounds were tested: three spoken messages, eight non-speech tones and one earcon illustrating a braking noise. They were evaluated according the procedure specified by Tan and Lerner [3] where participants rate each sound according to 13 statements regarding confusability, attention-getting, annoyance, appropriateness, etc.

This activity was conducted in the framework of PRReVENT (Preventive and Active Safety Applications) European Project [4], which is promoting the development, deployment and use of Intelligent Vehicle Safety Systems in Europe. In September 2007, a global Roadshow is being organised to exhibit results and demonstrator vehicles in which the following complementary fields are addressed: Safe Speed and Safe
Following, Lateral Support and Driver Monitoring, Intersection Safety, Vulnerable Road Users and Collision Mitigation.

**Keywords – interface, HMI, ADAS, speed, distance**

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**References**

Field studies on operating speeds and posted speed limit

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Abstract
It is generally acknowledged 85th percentile of speeds exceed posted speeds. Many research reports have also demonstrated that the 50th percentile operating speed either is near the posted speed limit [1; 2; 3; 4].

The goals of this research were to evaluate current procedures, especially how speed is used as a control in existing standards, and then develop recommended changes to the design process.

In this field studies we developed relationships between operating speed and posted speed limit; these relationships could be used to design roads that would produce the speed desired for a facility.

To accomplish these goals, the following objectives were met: review current practices to determine how speed is used as a control and how speed-related terms are defined; identify alternatives to the design process and recommend the most promising alternatives for additional study; collect data needed to develop the recommended procedures; develop a set of recommended design guidelines.

The experimental investigation has been conducted employing traffic counters, able to record, for every vehicular passage in both senses: length, instant speed and direction of the vehicle.

The plan of survey has been elaborated to satisfy different objectives of search (speed in free flow conditions, in entry and in gone out of the intersections, in rural to urban transition, etc.) and it has been applied to some roads belonging to the network of the Province of Salerno. The surveyed speeds concerned the minor rural roads SP30b, SP32, SP312, SP262 and the major rural roads SS166 and SS426, located in the “Piana del Sele” and in the “Vallo di Diano”. They are roads with one carriageway and two lane, situated primarily in rural environment, morphologically level or hilly terrain.

The traffic never exceeded 400 vehicles/hour during data collection. We always conducted the relieves in daylight conditions, with no rain and dry paving. The alignments of the highways are without spiral transition curves. The measures have been performed holding every station under observation for 2 or 3 hours [5]. We filtered preventively the data for getting a sample of transits really representative of the passages of cars in free-flow conditions. So we enucleated the only transits of vehicles with: length between 3.0 and 9.0 meters, as passenger cars; gap superior to 5 seconds from the preceding vehicle (absence of loan conditioning among the vehicles).

Plots showing the speed data by each site characteristic provide a visual appreciation of which variables may have an impact on speed.

The statistical analysis demonstrates that there is a relationship between the operating speed and the posted speed limit.
Assuming regression relationships, the study shows the results of the analysis that examined different percentiles. All models have good coefficient of determination values, indicating that free-flow operating speed are correlated with the posted speed limit.

The research demonstrates that the 85th percentile operating speed can be a factor in selecting a posted speed, generally being used as a starting point from which the speed limit is selected for a roadway.

Keywords – safety, design, speed, limit, behaviour

References

Comparative analysis of the attitude and behaviour of young drivers’ use of two-lane two-way highways

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Abstract

Road accidents have been one of the main causes of mortality worldwide for a number of years, with young drivers being over-represented in all types of accident including fatal ones. About 90\% of these accidents take place due to driver error [1]. The crash rates for 17 year olds is 50\% higher than that of 18 year olds, and the crash rate for 16 year olds is two and a half times that of 18 year olds\cite{2}. Young drivers have less experience compared to the older drivers in recognizing risky situations and acting accordingly to control the vehicle to the situation. Secondly they are immature and sometimes seek risks for their own sake, often not able or willing to think ahead to the potentially harmful consequences of risky actions. Teenagers were 10\% of the US population in 2004, but accounted for 13\% of motor vehicle crashes. About 54\% of teenage passenger vehicle occupant deaths in 2004 were drivers [3]. The National Highway Traffic Safety Administration (NHTSA) reported that drivers between 15 and 20 years of age account for 7\% of the licensed drivers, but they account for 14\% of the drivers involved in fatal crashes. It was reported that the drivers younger than 25 years old, represent less than 20\% of the driver population, but their crash rate is 3 to 4 times higher than the predicted crash rate [4].

In Texas, there are 3465 miles of two-lane two-way (TLTW) highways which comprise 62.4\% of the total rural highways (9). Most of the young drivers in this study need to commute to school by these TLTW highways. These highways have lower geometric design standards as compared to the freeways and hence, the crash risks are more. The most prevalent forms of behavior reported by young drivers and studied in this paper include excessive speeding, cell phone use while driving, driving under the influence of alcohol, tailgating, failing to use seat belts, failure to yield the right-of-way for other road users and running stop signs. The main objective of this paper is to study the attitude and driving behaviors of young drivers age 16 to 25 years on TLTW highways. The study is based on the results of a survey of a random group of young drivers from South Texas.

This study evaluated the dependence of gender on the behavior of young drivers on TLTW rural highways.

The findings of this study may be used for educating young drivers to minimize dangerous driving attitudes such as, underestimation of the risks while talking on cell phones and driving, speeding, tailgating, drinking and driving, or driving without a seat belt.
The results can also be used to create awareness of the importance of obeying traffic laws to improve traffic safety for all drivers.

*Keywords – young driver, driving behaviour, tailgate, yield, stop sign*

**References**

Validation of driving simulators:
physiological responses to virtual events during simulated driving

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Abstract

Driving simulators are perceived as an important tool to researchers who study driving. The technological
sophistication of current simulators provides a higher degree of fidelity than ever before, and the
programming flexibility allows researchers to test drivers in a variety of situations that could not be
examined safely on the road. One frequently cited drawback regarding simulators, however, is the paucity of
data on their validity as surrogates of real driving. We focus on that issue in this presentation.

An important aspect of simulator validity is the extent to which operators become immersed in the virtual
environment. This level of immersion, referred as “presence” by some [1], reflects the extent to which one
behaves in one environment (the simulated drive) as if he or she was in a different environment (the real
life). Thus, one important approach to support the use of simulators as adequate surrogates for the real
driving environment is the quantification of the level immersion of simulator operators.

One way to assess the level of immersion is by measuring the stress response to virtual events during
simulated driving.

Others have demonstrated that stressful situations in a real driving situation elicit a stress response. For
example, maneuvers such as overtaking and driving at high speed create stress responses [2; 3].

Several physiological measures can be used to indicate a stress response (e.g., heart rate, blood pressure,
breathing rate, galvanic skin response [GSR], hormone production), and researchers [4; 5] have argued that
these measures should represent valid and reliable measures of immersion in the virtual environment. The
goal of the studies we report was to document physiological responses to challenging situations in a
simulated driving environment.

We hypothesized that the operators’ responses would be similar to those expected to occur in a real driving
environment.
To test this hypothesis we used different simulated paradigms to evoke physiological responses. Specifically, we embedded several situations requiring action from the operators while driving a typical road circuit. In one such study we embedded three stressful situations.

In one situation a car pulled out unexpectedly in front of the operator, requiring an avoidance maneuver, and in the other two situations the operator was faced with green lights changing to yellow and requiring a rapid breaking response. We recorded beat-by-beat heart rate (HR) and breathing rate throughout the sessions. In response to the events the typical operator experienced a 4 beats/minute increase in heart rate and a 6 inhalation/minute increase in breathing.

These data, and others to be presented, suggest that operators are immersed to some degree in the virtual environment. It is not clear how the physiological responses reported here compare in magnitude to what we would observe during real driving, and we cannot address this question directly with studies on the road. However, we are currently attempting to address this issue indirectly with the use of a metabolic analyzer that allows us to collect heart rate and breathing rate data during both on-road and simulated driving.

Keywords – simulators, validity, presence, heart rate, physiology

References


Tunnel in fire: evaluation of different VMS warning message by driving simulator

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Abstract

Generally fewer accidents occur in tunnels than on open roads, however, if an accident happens the outcomes are more serious. The consequences indeed can be extremely destructive and dangerous especially in case of fire, because the enclosed space hinders the heat and smoke dissipation. Moreover, access limitations for fire-fighting and rescue operation, difficulty in ensuring safe escape route of the tunnel users increase the severity of the accident. Fires in tunnels endanger the lives of users (221 lives lost in Mont Blanc, Tauern, Kaprun and Gotthard tunnel fires over a period of just two years), and can also cause the damage to the tunnel structure with the very prejudicial consequences on the capital represented by the tunnel. In view of this, it is essential to prevent accidents in tunnels and provide adequate measures for tunnel users to escape or to be rescued by fire brigade. The safety measures in road tunnels fall into two categories: reduction of the probability of an accident (tunnel design, traffic regulations, facilities installed in a tunnel and maintenance) and reduction of the fire consequences (installing emergency facilities and constructing fire-resistant tunnel). These measures are not sufficient to guarantee the users survival if people react late (the first 10-15 minutes of an event are crucial in terms of self-rescue and limiting damage) or adopt dangerous behaviours like to wait inside or beside the vehicle, to exit from the escape ways and to return inside the tunnel, etc. These drivers behaviours are due to the difficulty of perception and acknowledgment of alarm signals, to the incomprehension of the risks, to the lack of knowledge about the correct behaviour to adopt and to the stress. The reduction of accident number and their severity can be obtained providing the users with early understandable warnings and clear instructions on how to respond to different emergencies.

This study investigates the drivers comprehension and behavioural responses to different dynamic and real time traffic warning information displayed by Variable Message Signs (VMS). A fire in tunnel situations with smoke-effect was simulated using the dynamic driving simulator of TEST laboratory. Alternatives VMS “warning-fire” messages were developed and evaluated by driving through the virtual tunnel in various scenarios. The collected data on driver behaviour concerned were qualitative (video, verbalisation at driving time, interview before and after driving) and quantitative (speed, deceleration, reaction time, lane position and change, actions on wheel and on pedals, etc). They were used to establish the safety effectiveness of the considered VMS messages. The results obtained show that in emergency situation an easy and complete information has a significant impact on driver behaviour and consequently on tunnel safety. Moreover, the study carried out put in evidence the easiness of evaluating new solutions by using advanced driving simulators.

Keywords – driving simulator, road safety, VMS, fire in tunnel
References

Road intersection prioritization through traffic impact and risk assessment analysis

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Abstract

The present paper aims at the development of a decision – support framework that enables the identification and a priory evaluation of measures for the improvement of road safety at accident – prone sites in an area. The framework consists of three main calculation modules. The first module involves statistical analysis methods, which are used for the prioritization of intersections, depending on their accident indices.

Based on a further analysis of the accident attributes, as well as the road geometry and traffic characteristics, the succeeding modules are implemented. Alternative road safety measures are considered, and their effectiveness is estimated, assuming a reduction in the expected number of accidents, as prescribed by each of those measures from application at similar situations. The second module is an econometrical module, which calculates the costs of the implementation of the measures, and consequent savings, owing to the expected reduction of the number of accidents. Furthermore, the third module is based on traffic engineering analysis principles, and is used for traffic impact assessment at the intersections, before and after the implementation of the road safety measures.

Finally, a fourth module, similar to the first, is run, to test the statistical significance of the accident number reduction.

The framework has been implemented in an urban area. After prioritizing the intersections based on road safety parameters, and processing all the data required for the next modules, the effectiveness and efficiency of road safety measures was assessed through the estimation of savings in accident costs and traffic implications. Finally, the certainty of the impact of the measures to the reduction of the accidents was addressed. The results of the above implementation will be presented in the full paper.
Safety assessment of barrier toll plazas

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Abstract

The future of the barrier toll plazas on the Garden State Parkway is currently a subject of discussion in New Jersey. Taxpayers, expecting an efficient and safe transportation system, have expressed concerns that barrier toll plazas are creating more costs than just a 35-cent toll. Groups who support keeping the toll plazas such as NJTolls.com are challenged by groups such as Citizens Against Tolls, resulting in a politically sensitive situation. Recent improvements including the introduction of Electronic Toll Collection (ETC) completed in 2001 have been followed by discussions of Open Road Tolling (ORT) or removing the toll plazas completely.

The issue is whether the revenue generated by the tolls is worth the social costs associated with them – namely delay, accidents, and pollution.

This study will focus on the cost of accidents associated with the barrier toll plazas on the Garden State Parkway.

The study focuses on the following seven questions:

1. Are there more accidents at toll locations?
2. Was there an increase in accident rates at toll plazas after the implementation of ETC in 2001?
3. Does the accident rate at toll plazas associated with ETC depend on Market Penetration?
4. Does ETC affect the severity of accidents?
5. Do toll plazas have an effect on the causes and types of accidents?
6. Does ETC affect the causes and types of accidents occurring at toll plazas?
7. Are there more accidents at toll plazas and/or after the implementation of ETC, and what are the increased costs associated with these accidents?

A review of previous studies determined the need for investigation as well as providing a means of comparing results. Sections of the Garden State Parkway were then selected and labeled as toll and non-toll areas. Non-toll areas of similar traffic volume and travel conditions to toll areas provide an appropriate means of comparison. Accident data between 1998 and 2002 was obtained to provide a comparison for the effects of ETC on the accident rate. The data was then analyzed to answer the above questions in terms of changes in accident rates both between toll and non-toll locations and before and after the implementation ETC. Finally, a regression model was developed to determine what variables influence the accident rate at toll plazas on the Garden State Parkway.

The goals of this study are to provide information on the differences in accident rates at toll plazas compared to non-toll sections of the Garden State Parkway and to determine if ETC has reduced delay at the expense
of safety. The difference in accident rates represent how many more accidents are occurring at tolls than would be occurring if the toll plazas were removed and the toll section was just another typical section of the Parkway. A cost of accidents will then be estimated based on these findings.

Keywords – barrier toll plaza, before and after, safety, removal, accidents

References

The efficacy of restraints in preventing child motor vehicle occupant fatalities

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Abstract

Road traffic accidents kill children as the leading cause of death in industrialised countries. For example, being a motor vehicle occupant is the most common mechanism of unintentional injury-related death for children aged less than 15 years in the United States [1].

Restraints, including child restraints and seat belts, are the most common occupant protection devices [2]. It is well established that use of seat belts by young children increases injury risk in a crash compared to using child restraints [3].

However, recent investigation of whether seat belts provide sufficient protection to save lives compared with child restraints has produced inconsistent findings for younger children [4; 5].

This study aims to evaluate the effectiveness of seat belts and child restraints, when used, in preventing death for child motor vehicle passengers.

We conducted an in-vehicle matched cohort study within a cohort of child motor vehicle passengers aged 0-8 years, who were rear-seated in passenger vehicles and involved in fatal traffic crashes in the United States during the period 1998-2005. Allowing for potential effect modification, crash- and vehicle-related characteristics were also taken into account. Cox proportional hazards regression method was used to estimate mortality rate ratios (RR) and 95% confidence interval (CI) for death within 30 days of a crash in relation to the restraint exposure.

For the study population of 3042 child passengers, using child restraints provided significant life-saving effects compared to no restraint use in all fatal crash scenarios; whilst wearing seat belts didn’t differ from no restraint use in non-rollover traffic crashes for those who were travelling in passenger cars (RR: 0.77, 95%CI: 0.52-1.14) or utility vehicles (RR: 0.49, 95%CI: 0.21-1.11). Within a subset of children aged 3-4 years, neither seat belts nor child restraints differed from no restraint use in preventing deaths. Overall, child restraints performed better than seat belts in preventing deaths, although not statistically significant. In conclusion, we gave evidences that seat belts failed to provide adequate protection in preventing child passenger deaths in all crash circumstances.
Results will be discussed in terms of implications for appropriate use of restraint for child vehicle passengers.

Keywords – child, passenger, seat belt, fatality, risk

References

Anatomization of road traffic offences as a panacea for road traffic safety

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Abstract
Motor vehicle use as a means of transportation has the major advantage of enhancing economic and social development of our society. However its operation is fraught with dangerous consequences for human and the environment.

According to Ogunsanya [2003], hardly can any family within Nigerian State be found that has not lost someone or properties to automobile crash. That on hourly basis, helpless Nigerians are unfortunate victims of road accidents.

As charred carcasses of crashed vehicles filled our highways, so also are the mangled bodies of auto crash victims. Hospitals are filled with the wounded, with various degrees of injuries. This ugly scenario in many cities would have been avoided, if some people were careful enough to obey traffic rules and regulations. The disturbing situation is that, despite the various traffic rules and regulations made to ensure safety on Nigerian roads, available statistics showed that the carnage on the roads have continued to increase.

Also, human being are the prime factor in highway traffic, therefore their discipline and obedience to traffic rules and regulations are very significant in the safety of life and properties on the roads.

It is against this background that this paper examined the violation of traffic rules and regulations by motorist in a selected major corridor in Kaduna city of Nigeria.

The examination and analysis of traffic offences is used as a panacea for accident reduction and traffic safety in Kaduna city in particular and Nigerian cities in general.

Finally, Kaduna like Lagos, the business capital of Nigeria possessed various traffic problems which may not be particular to it. This is because various studies on accident showed that traffic accident in Kaduna city are linked mainly to human factor, which is summed up as total disregard to traffic rules and respect for other road users. Consequently this paper analyzed the traffic offences with major objective of finding answers to the research question; If enforcement of traffic rules can be increased and efficiently done, would the accident rate reduced and traffic safety increased.

In conclusion the effect of traffic rules on accident were also examined.
References


4. Ogunsanya A A [2003]: "Maker and Breaker of Cities" 59th Inaugural Lecture at The University of Ilorin Ilorin Nigeria
Calibration of IHSDM crash prediction algorithm for Italian rural two-lane highways

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Abstract
The software analysis tool IHSDM [1] can be used for evaluating safety and operational effects of geometric design in the highway project development process; it is based on statistical models and algorithms that allow to estimate safety performance of roadways [2; 3].

Crash Prediction Module (CPM) included in the software provides estimates of expected crash frequency and severity of crashes that would be expected on rural two-lane highways considering its geometric design and traffic characteristics [4]. In way to allow potential users of the CPM algorithm to scale the crash predictions to be suitable for the specific road analyzed, CPM provides a calibration procedure which enables to consider several factors that are not directly accounted for by the crash prediction algorithm like differences in climate, animal population, driver population and accident reporting threshold and practices.

In order to use the CPM to estimate the total crash frequency during a specified period on rural two-lane highway segment of the Italian context, it’s necessary to calibrate the prediction algorithm; but the implementation of the calibration procedure proposed by CPM would develop misleading results.

The CPM algorithm provides an estimation of the whole number of crashes independently from the severity, but in order to work with a homogeneous and reliable sample of data it may be better to use only injuries and fatal crash data.

In this study, the CPM module has been calibrated by using injuries and fatal crash data collected on two collector rural roads in Tuscany. Data collected for a 4 year period have been used to predict crash data for the 5th year and predictions have been compared with collected data; by this way a correction factor have been determined that allows the CPM to estimate the crash frequency on rural two-lane highway segment of the Italian context taking into account only injuries and fatal crashes.

Keywords – safety, rural two-lane highway, IHSDM, CPM, crash frequency
References

Characterization of bridge rails concrete slab support in finite element simulation tools

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Abstract

Bridge rails are usually installed on existing structures than can differ considerably from the supports used during the full scale crash tests conducted on the rail according to EN 1317 standards. This difference can be related to the geometry of the support or to the resistance of the cement concrete and results in a reduced resistance of the overall support in the event of a crash.

It is therefore extremely important to be able to model the influence of this difference in the support on the performance of the barrier during an impact of an Heavy Gross Vehicle (HGV) to evaluate if there is a need for any structural reinforcement on the bridge deck or in the anchoring system.

Currently such models are not available as, even in the more advanced simulation tools, the support is often considered as a “boundary condition” without the characterization of the physical properties of the concrete slab.

To solve this problem a study has been performed combining full scale testing on bridge rail posts on concrete slab supports with numerical simulations in Ls-Dyna environment.

To develop an integrated vehicle-rail-slab model a number of issues had to be tackled. Among the others:

- there is currently no standard materials card in Ls-Dyna capable of correctly representing the cement concrete behaviour (strongly asymmetric in the tension/compression domains) up to the rupture thresholds. This is an extremely important issue in crash simulations where the extreme conditions have to be tested, far beyond the elastic domain;
- a fully integrated model with the concrete slab modelled in the FEM structure, as the barrier and the vehicle, results to be extremely heavy and the calculation time allows only for a limited number of trials, even in the network of multiprocessor servers running in parallel in the computational laboratory of the Road Engineering Area of the University of Florence.

For these reasons it was decided to split the model in two parts developing, as a first part of the study, a model representing a single post anchored on a concrete slab. This model has been developed based on the results of literature pull out tests and it is under validation by means of a full scale experiment where a “boogie” is being used to impact a single post (with the same characteristics as the posts of the full barrier) anchored on slabs with different geometries and different cement concrete resistances. To conduct the validation activity a FEM model of the boogie in LsDyna environment is being realized and simulation of the full scale boogie to post impact are conducted.
The post/slab model is then being integrated in the full barrier/slab model and the validation is then conducted on the results of the full scale test conducted in a Crash Testing Facility according to EN1317 standard with the impacting HGV fully modelled in the Ls-Dyna environment.

Keywords – safety barriers, Ls-Dyna, crash tests, numerical modelling, concrete slab

References
1. CEN/TC226/WG1, EN 1317, “Road restrain systems”
2. Bonin, Ranzo "Dynamic actions on bridge slabs due to heavy vehicle impact on roadside barriers", Transportation Research Record No. 1890 2004
3. CEB "Fastening to Concrete and Masonry structures" -1988
The program for the specialization of Spanish civil engineers in road safety

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Abstract

Spain is experiencing an extraordinary period of time in the construction sector. The young civil engineers can choose between a wide variety of opportunities at the beginning of their professional careers: buildings, roads, bridges, railway, ports, etc. There is enough work for Spanish civil engineers in Spain, and also abroad. That is one of the reasons why there is a lack of young civil engineers specialized in Road Safety in Spain.

Due to this situation, in 2006 the Spanish Road Association led an initiative called “Program for the specialization of Spanish civil engineers in road safety”. The aim of the Program was to choose a group of civil engineers with enough experience in Road Safety and send them to some of the best Research Institutions in Europe, in order to learn the latest trends and studies in this area.

The objective of this Program was spread among the members of the Spanish Road Association, both from the private sector and from the public administration. There were some requirements that had to be fulfilled by the candidates:

- To have enough experience in the field of Road Safety.
- To speak the language of the country where the Research Institution is.
- To have a commitment to work for at least 3 years in Road Safety issues.

A lot of applications were submitted by engineers who worked in private companies and in the public administration. The final team of Spanish researchers was composed by 4 engineers: 2 from private companies and 2 more from the General Traffic Directorate.

Finally, the companies and Institutions chosen were:

- Institute for Road Safety Research (SWOV). The Netherlands.
- Institut National de Recherche sur les Transports et leur Sécurité (INRETS). France.
- Swedish Road Administration (SRA). Sweden.

Two members of the team were sent to the Institute for Road Safety Research (SWOV) in The Netherlands, one to the INRETS in France and another one to the Swedish Road Administration (SRA), in Sweden. The period of time that each engineer was researching in his or her chosen Institution was varied between 2 and 3 months.

The second part of the presentation will be dedicated to my professional experience in the Swedish Road Administration.
For 3 months I had the opportunity to research road safety issues in Borlänge (Sweden) -the city where the SRA’s Headquarters are-, but also other aspects such us: landscape architecture, cost-benefit analysis, design of roads and streets, etc.

On October 9, 1997 the Road Traffic Safety Bill founded on "Vision Zero" was passed by a large majority in the Swedish Parliament. This represents an entirely new way of thinking with respect to Road Safety. My main objective was to learn the process of Vision Zero, from the concept to action, in order to verify if some of the initiatives launched with this new philosophy could be implemented in Spain.

Keywords – Sweden, Vision Zero, research, road safety, specialization

References

4. The National Society for Road Safety: http://www.ntf.se/
5. The Swedish National Road and Transport Research Institute (VTI): http://www.vti.se/
Slovenian fifteen years experiences with roundabouts

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\textbf{Abstract}

During the past fifteen years in the Republic of Slovenia roundabouts have become more and more interesting for both designers and investors. Earlier in Slovenia we practically had no significant experiences with roundabouts and their advantages in road traffic. Nowadays, fifteen years after building the first roundabout within the so called "new wave", we have 102 roundabouts and several more under construction \cite{1; 2}.

When Slovenia became an independent country in the beginning of the 90s, the need for establishing new legislation for the field of road design and road traffic appeared. Among many other measures, the Slovenian Ministry of Transport founded the "Working Group for Roundabouts" and its main task was preparation of guidelines for planning and designing of roundabouts. The Group finished its work in May 1999 and the final version of guidelines was accepted in May 2000 \cite{3}.

Approximately fifteen years after the "new wave" of roundabouts has flooded Slovenia, in the moment when there are hundred and two roundabouts installed all over the state and when the further increase of their number is foreseen \cite{3}, there is an opportunity for a general review of process concerning roundabouts in the Republic of Slovenia, special from a traffic – safety point of view.

Considering the chronical lack of professional literature on roundabouts in the first stage, the excess of professional literature, manuals and guidelines by other countries in the second stage, the lack of our own guidelines for roundabouts in the third stage and the number as well as the consequences of traffic accidents, we can affirm with complete responsibility that both designers and contractors have performed their work professionally, with a high level of quality.

The process of introducing roundabouts in the Republic of Slovenia had a number of participants, who, although a little later, also joined in. Without their co-operation, the process would have been much less successful.

These are the road-police, media, driving schools, etc. Especially media, unlike driving schools, are the major source of providing information to the largest number of users – PCU drivers, pedestrians, as well as cyclists.

In the paper the Slovenian experiences in roundabouts in build up areas and measures of assuring a traffic safe roundabout are presented.

\textit{Keywords} – roundabouts, build up areas, implementation, traffic calming, performance
References

3. Tollazzi T., “Reduction of the roundabout capacity due to pedestrians or cyclists = Influence des piétons et/ou des cyclistes sur la sécurité et la capacité des giratoires = Disminución de capacidad y seguridad del rondo por los peatones y bicicletistas, Urban transportation and environment, proceedings of the International conference CODATU IX, Mexico city, Mexico, October 2000
The proposition for improvement the procedure for eliminating the dangerous road locations on state road network in Slovenia

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Abstract

Slovenia is, like other new EU Member States, aware of its tasks for improving traffic safety. In accordance with very clear demands of European transport policy [1] about road safety – that is an EU recommendation of halving the number of road accident victims in the European Union by 2010 – Slovenia has also put into its national program [2] a decision to halve the number of dead casualties on Slovenian roads.

Unfortunately, the current situation in the field of road safety in Slovenia is - despite the highly ambitious plans - still not satisfactory. It has to be admitted that traffic safety in Slovenia has been improved during the last years but we still have not achieved the objectives of reducing road accidents, injured participants or dead casualties.

One of the "steps" to achieved desired level is also to improve our existent road infrastructure. Road infrastructure improvement supposed to be applied to hazardous locations first. For safety management it is well known, that we have three main motives for safety management [3]: economic effectiveness, professional and institutional responsibility, and fairness.

Survey among 25 EU states [4; 5] about estimating the most effective short, medium, and long term measures, both at national level and at EU level shown, that measures related to Infrastructure Safety Management, such as High-Risk Site (Black Spot) Management, Road Safety Audit, and Road Safety Inspection, are generally recognized as a high priority. While High-Risk Site Management is a short-term measure, other Infrastructure Safety Management measures make their impact in the medium to long term. Most of the infrastructure tasks are to be realized on the national level.

In Slovenia we have our methodology for eliminating dangerous sections / intersections - "black spots" - on our national roads. In the paper we present the strategy of dealing with this process in Slovenia. It is composed of several phases and it has its own advantages and disadvantages. Based on several years of experiences of co-operation in the process of eliminating hazardous locations on state road network in Slovenia in the paper we analyzed current process and proposed necessity modification in current process of dealing with hazardous road locations on state road network in Slovenia.

On the basis of the analysis advantages are presented, but first of all the article describes disadvantages and problems that all participants constantly deal with in the process of elimination of hazardous locations on
Slovenian state road network. Because of these problems reconstruction of hazardous locations can be significantly more difficult and the whole process of their elimination less efficient.

At the end a proposal for improvement of the existing procedures in the process of reconstruction of hazardous locations is given based on the analysis of already established procedures at home and abroad.

**Keywords** – traffic safety, highway safety management, hazardous locations, black spots

**References**

2. Resolucija o nacionalnem programu varnosti cestnega prometa za obdobje 2007 - 2011 (Skupaj za večjo varnost) (ReNPVCP), *UL RS 25/06, 2006*.
Determination of the risk factors for small car crashes in Malaysia

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Abstract

Over the past few years, the tremendous increase in the number of registered small cars in Malaysia has raised concerns about the already high number of small cars involved in road accidents. A study conducted for a report to the Ministry of Transport [3] indicated that 40\% of motorcyclists have access to cars as an alternative mode of transport. This impending increase in the number of car drivers amplifies the likelihood of a corresponding increase in the fatality rates of small car crashes.

It has been extensively reported that in dangerous collisions which involve small cars, the occupants of the small cars are more likely in dangerous situation to be exposed to injury compared to the occupants of bigger cars [2; 4].

In Malaysia, small cars registered in year 2005 were recorded 36.5\%.

This figure significantly amplifying the motorcars involvement in road accident which was recorded 9.7\%. Therefore, there is a need to reduce the substantial increase in highway losses involving small cars accidents by understanding the crash patterns of small cars.

This paper is devoted to an in-depth study on small car crashes in order to determine, and then evaluate the factors that influence the occurrence of such accidents.

In the study, small cars are categorised according to their mass, curb weight and wheelbase, that is, according to engine capacities of 1000cc or less, a wheelbase length of 2500 mm or less, and curb mass of 900 kg or less.

A total of 116 cases of small car crashes were collected and crash data were retrieved. The collected samples of real-world small cars crashes were then divided into two groups, namely, injury accident and non-injury accident. Damaged vehicle inspections and casualty interviews were conducted and then tallied with respective police reports. Of all the crash cases, 61 cases were successfully identified as being suitable for the present study. These cases enabled the establishment of damage profiles [1] which were further analysed with the help of AiDamage, a computer software for crash and dynamic analyses. Out of the 61 cases, a total of 29 were injury cases and 32 were non-injury cases.
A number of factors were studied and these were:

1) Characteristics of drivers, which comprised (i) gender (ii) age (iii) height and (iv) weight;
2) Small car factors in terms of (i) year and model (ii) seatbelt occupancy (iii) engine capacity, and (iv) wheelbase;
3) Crush exposure of the crashes, which involved (i) collision type (ii) change of velocity (ETS) (iii) damage extent, and (iv) damage length,
4) Environmental conditions at the sites of the crashes, which were (i) time of accident, and (ii) road geometry.

The cluster bar chart and cross tabulation analysis were carried out to determine the significant risk factors for accidents involving small cars. The findings have concluded that the factors that significantly affected small car crashes are gender, model of vehicles, collision type, change in velocity (ETS), and damage extent.

Keywords – risk factors, crash patterns, small car crashes, collision deformation classification.

Acknowledgement:

The authors would like to thank the Ministry of Science, Technology and Innovation (MOSTI) for providing funding for graduate studies at Universiti Putra Malaysia to the first author, and to the Kuala Lumpur Police Department, Petaling Jaya Police Department, Kajang Police Department, Klang Police Department, Seri Kembangan Police Department and Bukit Aman Head Quarters of Royal Malaysian Police, last but not least to Mdm. Rogaya from Malaysia national small cars manufacturer (PERODUA Bhd.) for providing the data for the study.

References

The importance of information in road safety: the special operation Paso del Estrecho

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Abstract

Geographic Spanish location supposes Spain is a link for traffic flow between Central and Northern Europe and the North of Africa. During summer holidays, this traffic flow increases in a very important magnitude as people from Africa that works in Europe returns to their origin countries. This traffic increases have a high impact in road safety due mainly to the special features of road users: long distance crossed, drivers arrived so tired and cars are overloaded. [1]

To solve or minimize the problems produced by this summer event, Dirección General de Tráfico (DGT), the Spanish traffic organizations, leads the special operation \textit{Paso del Estrecho} in coordination with different organizations (emergency services, civil protection, road maintenance, red cross, etc.).

The operation is developed in two main long-distance corridors that cross Spain from north to south. One of them, crosses the central area of the country: departing from Irun, going down the N-1 until reaching Madrid and then through Bailen, Granada and Malaga to Algeciras. The second corridor is in the northeast, from the frontier with France in La Jonquera, going down the Mediterranean corridor, the A-7/E-15 (Barcelona, Valencia, Murcia) and, finally, the A-92 until Algeciras.

DGT is developing different traffic management activities in the frame of especial operation Paso del estrecho [2].

These activities are focused to inform users about traffic status and road safety.

The information is related to: traffic status, travel times and special rest areas through corridors, traffic status and parking areas nearby main harbours.

In this paper the operation especial \textit{Paso del Estrecho} will be presented, including the different traffic management strategies and its influence in road safety.
The traffic strategies are focused on road monitoring, coordination at different levels (local, regional and international) and the diffusion of traffic information to road users.

*Keywords – traffic information systems, road safety, traffic management & control*

**References**

An expert monitoring system to work with snowfalls

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Abstract

The weather-related problems happened in the latest years have led to various problems on the road network: closed roads, trapped vehicles, accidents with injured people and casualties and important economic losses. The negative effects derived lead to the higher risk of a traffic accident due to the lack of visibility and adherence on the pavement together with the lack of ability of the road users, who are not accustomed to driving under such conditions [1].

These emergencies situations have a big impact in the society, so public organizations have to work with to guaranty safety when a snowfall emergency situation is produced [2].

The Traffic Management Centre in Valladolid has a strategic place between Portugal and France. It is a very driven area, mainly for heavy vehicles, due to the transport of merchandises between the different countries. The Traffic Management Centre in Valladolid is a centre that is especially bound to low temperatures and snow falls.

Frost, sleet and snow are common between 15 and 30 days a year depending on the areas. It should also be pointed out that frosts and snow get worse at night time, while the driving re-establishment is more complicated due to the difficulties derived from working with such unfavourable conditions and the high risk existing.

In the frame of traffic management, the Dirección General de Tráfico (DGT) works actively in the development of systems and traffic management plans in case of snowfalls. It is therefore necessary to know where, when and how to act efficiently making use of the ITS systems available. The objective is to improve the road safety, minimize the impact of the snowfall and all weather-related events and guarantee feasibility in the largest possible number of road stretches [3].

The main purpose of this paper is to present the Spanish approach to work with snowfall emergencies in order to improve road safety.

First, an analysis of snowfall emergencies at national level will be exposed. Second, the traffic management strategies will be presented, including the development of an specific ITS to detect the location and the influence of the incident produced by weather problems. Finally, the results of the system application during 2006 will be analyzed.

Keywords – monitoring system, road safety, weather problems
References


Abstract
A human being receives information important in a car driving situation in a discrete way, moving the sight from one part of space to another one without focusing on the space between the parts. High speed of eye movements and “visual inertia" of the eye (maintaining the picture for a while) allow us to perceive the visual information in the discrete way [2; 3]. This finding is the basis of our concept of car driving simulators, which will require moving the sight to these parts of the space where are the sources of information about the traffic lights and other cars. We have worked on three versions of simulators that enable testing traffic lights responding (simulator I); line and direction changing and traffic lights responding to discrete (simulator II) and analogue (simulator III) stimuli presentation.

The location of the external information sources important while driving a car will be similar to a real-life situation (in the front and on the sides of driver). In the discrete stimuli presentation the information does not change (constant picture of a car), while in the analogue presentation the information changes (a film of moving car) in the time. In this paper we present the concept of simulator I.

The simulator is based on using the psychomotor efficiency timer [1], which consists of a computer, a controller and a measurement station containing a traffic lights presentation board and a leg responses sensor board. The presentation board has the shape of a traffic lights box and is located in front of a subject in the vertical plane. The sensor board is put on a floor. The location of the sensors (tactile) on the board is like the accelerator and the brakes pedals in a car. The subject’s task was to respond to 3 colors of traffic lights: green, yellow and red. The yellow light was presented in two sizes: small (crossing is far away) and large (crossing is very close). Subject task was to displace the right foot from the accelerator to the brakes pedal as fast as possible, when the red or the small yellow light was presented. Green light stimulated the foot displacement from the brakes to the accelerator pedal. Releasing the brakes pedal, when the red light appeared, or the accelerator pedal, when the green or large yellow light was presented, was treated as a error. The number of wrong decisions (errors - E.), foot movement initiation (MIT), execution (MET) and total (MTT=MIT+MET) time (in ms) was tested. MIT was measured as time elapsing from the presentation of stimuli till releasing the sensor by the foot; MET from releasing one sensor to touching another one. Subjects responded to 12 stimuli (irregular presentation of red, 2 yellow and green light) in 6 series (3 practice and 3 measurement trails). We have examined whether the speed and correctness of responding to traffic lights on the simulator differentiated people who can and cannot drive a car. 27 car drivers and 21 “not drivers” (ave.
age of 22.6 and 22.5 years old respectively) participated in the study. Car drivers had 6 years car driving experience and have driven on average 12.2 thousand km per year. The research has shown shorter movement execution (MET) and total (MTT) time in the car drivers group, when responding to the red light and the small yellow light. Not car drivers made double more errors (6) than car drivers (3) in responding to traffic lights.

The simulator differentiated car drivers and not car drivers with respect to the speed of foot displacement on the brakes pedal in response to the red (stopping the car) and the small yellow light (preparing to slow down the car) and to the correctness of reacting to traffic lights discrete changes. Simulator I can be used as a diagnostic and training device to test the influence of different factors on the speed and accuracy of traffic lights responding and to practice the speed of reacting and correctness in decision making in advanced age. The simulator can be particularly useful for testing and practising the speed of reacting of tramway drivers, who do not have a steering wheel in the tramway.

Keywords – car driving simulators, discrete perception, traffic lights responding, concept

References

The influence of age and sex on the speed and correctness of responding to traffic lights tested in simulatory conditions

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Abstract

Aging causes changes in the central nervous system and in muscles composition and activation. Reduction of neurons occurs in brain regions related to learning, planning, initiating movements [1]. Aging changes in the motor system are connected with the loss of muscle mass and lower velocity of contracting muscle fibers [2]. The purpose of this study was to test age and sex differences in the speed and accuracy of responding to traffic lights changes. 16 elderly subjects (av. age of 63.6 years old) and 28 young subjects (18 males, 10 females – av. age of 22.4 years old) participated in the study. The period of driving a car and the car driving distance per year was 29.3 years and 11.5 thousand km in the older group and 4.0 years and 11.9 thousand km in the younger one.

A car driving simulator I was used in the study [3]. It consisted of a computer, a controller and a measurement station, which contained the traffic lights presentation (stimuli) and leg responses (sensor) board. The stimuli board was located in the vertical-front plane of a subject (in sitting position). The response board with two tactile sensor was put on the floor. The sensors were located on the board like the accelerator and the brakes pedals in a car. The following traffic lights were presented: green, yellow (small and large) and red. The small and large yellow light indicated that the car is far away (small light) or close (large light) to crossroads or a crosswalk.

The subject’s task was to displace the foot from the brakes to the accelerator pedal as fast as possible, when the green light appeared and from the accelerator to brakes pedal, when red (stopping the car) and small yellow (preparing to slow down the car) light was presented. The brakes-accelerator (ba) and accelerator-brakes (ab) foot (displacing) movement initiation (MIT) and execution (MET) and total (MTT=MIT+MET) time were measured. The time of releasing the pedals was treated as MIT. MET was measured from releasing one pedal to touching another one. MIT, MET and MTT for the accelerator-brakes foot movement was separately tested for the red (r) and the small yellow (y) light stimuli. The number of wrong decisions (E) was also tested. An error occurred when the subject released the brakes or the accelerator pedal when the red light (brakes pedal) or the green or the large yellow (the accelerator pedal) appeared. Subjects performed 3 practice and 3 measurement trails.

In each trail 4 traffic lights (green, red, two yellow) were presented in an irregular way in a series of 12 stimuli. The average MIT, MET and MTT and E for 3 measurement trails were taken into consideration. We have found all three tested movement total times (MTTba, MTTab) longer in the older than in the young group (0.153 s, 0.2 s respectively) and in the female than in the male young group (0.1 s, 0.132 s
respectively). Young female slower than male drivers displaced foot from the brakes to the accelerator pedal (longer MET) and in the opposite direction. Older drivers slower than young ones initiated foot movement (MITabr – 0.115 s, MITaby – 0.105 s) and execute the movement in response to small yellow light (METaby – 0.1 s).

Female and male drivers make the same number of wrong decisions (3 for 20 stimuli), while elderly drivers 2.25 times more than young drivers (7 for 20).

The simulator applied in this study can be used to test the influence of different factors on the speed and accuracy of traffic light responding car and tramway drivers.

The presented study is a part of our work on elaboration of a battery of tests on human psychomotor efficiency fundamental for everyday activities.

Keywords – car driving simulator, response speed, traffic lights, sex and age differences

References
New model to estimate speed differential in tangent-curve transition

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Abstract

It has been shown that to improve road safety it is necessary to design in accordance with drivers' expectancies. This concept is known as Design Consistency. It derives from the evidence that a relevant quota of accidents is caused by inadequate information provided to drivers by the road, inducing a driving behavior often strongly different from that expected according to the design [1]. In order to avoid surprising events, the crucial point is that of limiting speed reductions by drivers between successive elements of the road alignment (called speed differential values).

In consideration of this, the road design guideline of several Countries, each with their own peculiarity, recommend in the process of road design: a) the estimation of the operating speed ($V_{85}$), considered as the expressive parameter of the driver’s behavior and defined as that speed below which 85% of passenger cars operate under free flow conditions; b) the analysis of the design consistency in order to check excessive differences of operating speed between successive elements along the alignment.

According the traditional approach the speed differential value is obtained by a simple subtraction of $V_{85}$ on two locations of successive elements. Previous researches [2] [3] [4] [5] highlighted that this methodology underestimates the amount of speed reduction experienced by the individual drivers.

An experimental study was conducted to define new model for estimating the speed differential value between tangents and curves, based on the speed profile of each driver along the tangent-curve transitions.

The CRISS (Inter-University Research Center for Road Safety) interactive fixed-base driving simulator was used. A model that predicts speed differential value between tangent and curve was developed by regression analysis of data recorded in the driving simulator. The comparative analysis between the proposed model and the predicting models available in literature highlights that the new model best reflect the real speed reductions experienced by drivers.

The result confirms the high potentials of the interactive driving simulation in order to evaluate the driver performance induced by the configuration of the road alignment and to avoid geometric combinations which can reduce road safety.

Keywords – driving simulator, design consistency, speed differential, driver’s behaviour
References

Driver training using fused reality

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Abstract

This paper describes a novel mixed reality technique for real-time color-based video processing for training applications using software and off-the-shelf hardware. This technique 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). Additionally, physical objects can be deployed real-time into the virtual scene (a person gesturing outside the simulator cabin can be virtually moved relative to the vehicle). The technique has been coined and patented by the author as “Fused Reality.” Fused Reality’s adaptive feature recognition allows for realistic set lighting, colors, and user movement and positioning. It also enables multiple keying colors to be used (vice just blue or green), which in turn allows “reverse chroma-keying” – preserving only keyed colors and rendering all others transparent.

The novel chroma-key method introduced in this paper will be applied to driver training, where driver performance using Fused Reality and STISIM will be compared for a variety of tasks and environments. Automatic shift, and a steering wheel.

Three display environments will be compared:
1) Image projection onto a medium field-of-view (FOV) screen;
2) Narrow FOV helmet mounted display (HMD) having a scene field of regard (FOR) equal to the screen used with the projected image;
3) Narrow FOV HMD with an unrestricted scene FOR.

Secondary tasks will be introduced, including dialing cell phones and map-reading. Driving scenarios will include:
1) Intersection turns;
2) Obstacle avoidance (path intrusion);
3) Day/night lighting; and
4) Overtaking/lane changing.

Hypotheses to be tested will include:
1) Fused Reality does not degrade the performance of tasks that require hand-eye coordination within the car (such as map-reading, cell-phone dialing), which will be indicative of Fused Reality’s functional realism;
2) Narrow FOV HMD’s and wide FOR screens produce equivalent driving performance; and
3) Narrow FOV/unlimited FOR HMD’s yield superior driving performance over medium FOR projection screens.

Quantitative (lane control, situational awareness, speed control) and subjective measures will be collected.

Keywords – Fused Reality, chromakey, driver training, helmet mounted displays, real time video editing
Wednesday 7th November 2007
Time 9:00 am
Preliminary Session
STISIM Drive Users Group meeting
Chairman – Mr. R. Wade Allen
Transfer of training effectiveness of a bus simulator

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Abstract

Accident rates amongst novice bus drivers in the first year of driving are significantly greater than their more experienced counterparts [1] and this may be due to many factors including time pressure and lack of experience in driving a bus in operational environments [2; 3].

To address this problem, Cranfield University’s Driving Research Group have developed a bus simulator funded by Arriva to provide additional training to novice bus drivers on the specific hazards known to be associated with (particularly culpable) novice bus driver crashes [4].

The hypothesis for this research was that simulator training can reduce novice bus driver accident rates when compared to the accident rates of traditionally trained bus drivers.

Simulator-based scenarios were developed, including an orientation trial followed by multiple exposures to simulator drives containing a high rate of hazardous and time critical encounters with traffic, pedestrians, junctions, varying roadway configurations and traffic control devices (signs, bus stops and markings). The main focus of the scenarios was to improve hazard perception; train decision-making and appropriate vehicle control response under time pressure.

Participants completed four trials after the orientation drive – a shortened bus route with no time restrictions, to assess how they behaved around locations with a high accident rates, then the same route with a ten minute restriction (the original route was approximately 15 minutes in length if driven safely) to highlight the decrease in driving performance, without a large decrease in time. These two trials were then followed by a hazard perception and following distance trial assessing how the participants behaved in more hazardous and frustrating situations. Feedback was provided on a number of performance criteria (accidents, speeding violations, lane position, braking and acceleration). The participants then repeated the first route until they reached performance criteria. Driving scenarios were 12-15 minutes long in duration. To assess the effectiveness of the bus simulator to reduce crash risk, a transfer of training study was designed and is reported in the present paper.

To assess the benefit of fidelity in transfer of training effectiveness, simulators with two levels of fidelity were used in this research including:

1) a desktop, triple monitor, wide field of view (FOV) configuration and
2) an instrumented bus cab with projected wide FOV.

All bus driver trainees took part in the standard 3 weeks of in-vehicle training at Arriva’s driver training school. After completing this training period, participants were randomly assigned to one of four experimental groups. Group 1 received moderate fidelity simulator and classroom based training. Group 2 received low fidelity simulator and classroom based training. Group 3 received classroom based training
only and Group 4, the control group, received the standard in-vehicle bus driver training only. Forty-eight drivers were assigned to each group.

After the study, drivers were then assigned to operational driving. For the following 12 months, accident rates will be monitored and analysed between the groups in three monthly stages. Compared with the control group, it is expected that participants trained with the wide field of view will have a lower percentage accident rate compared with the desktop configuration.

The paper will discuss the ability of bus simulator and classroom based training to improve bus driver safety, and how simulator fidelity impacts on training effectiveness.

Keywords – transfer of training, simulator, bus

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

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Abstract

Driving is important for a large percentage of the elderly population. Unfortunately, difficult driving contexts such as negotiating intersections and overtaking maneuvers [1] often challenge older drivers. These complex maneuvers need coordination between head and eye movements to bring the image of surrounding objects (most often neighboring vehicles) to the fovea (where they are best perceived and often processed at the cognitive level). For instance, before changing lanes the driver needs to inspect the rearview and left view mirrors and the blind spot by eye-head movements.

These perceptual processes are continual and make up the basis for complex decision making yielding to secure lane changing. With aging there are suggestions that drivers may display a perceptual narrowing [2]. The aim of the present study was to test the hypothesis that, before a left lane change, older drivers visually inspect three regions of interest (ROI; rear-view mirror, left-side mirror, and blind spot) less frequently than young and active drivers.

We tested young (N=12, age range = 20-24 years) and older (N=11, age range = 66-75 years) active drivers in a simulated environment (STISIM, v2.0) with identical controlled driving contexts.

The continuous scenario included 16 events where, to manage a secure lane change, the driver needed to inspect visually the three ROI. The lane change maneuvers were necessary

1) to avoid a static object that was partially or completely blocking a lane or
2) for overtaking a slower moving vehicle.

Data were also collected for straight road segments (n=4). For all events, video streams of the screen and of the driver (three different views of the head) were collected with digital cameras. A magnetic tracker (Flock of Birds) captured head movement (panning). All data (car and steering movements, head panning and video streams) were collected synchronously.

Compared with younger drivers, older drivers showed a reduced number of inspections towards the three ROI and this was particularly apparent for the rear-view mirror and the blind spot. Also, the frequency of visual inspection for the older drivers was constant across the two types of driving contexts (i.e., avoiding a static object and overtaking a slower vehicle) while the younger drivers showed an increased frequency
when the lane change was more complex and performed at a higher speed (overtaking vs. avoiding maneuvers). For instance, for the older drivers, only 26% of the events needing overtaking a slower vehicle included a specific visual inspection to the blind spot. Remarkably, when a visual inspection was noted, it most often occurred during rather than before the onset of the lane changing.

On the contrary, for the young drivers, 94% of these events included a specific inspection to the blind spot and the head movement always preceded the steering response leading to the lane change. These observations, although collected in a simulated environment, point towards ill-adapted scanning behaviors for the elderly drivers.

**Keywords** – aging, visual inspection, head movements, lane changing

**References**

The relationship between chronic sleep deficit and distractions in young adults

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Abstract
Several variables have been investigated in an attempt to explain the high rate of vehicle crashes for young drivers. These include inexperience, driving fast [1], inattention [2] and sleepiness related to time of day [3]. Most studies investigating the relationship between sleep and incidence of vehicle crashes among young adults have concentrated on the effects of acute sleep deprivation on driving behaviour [4]. This study reports the relationship between chronic sleep deficit and distractions on driving mistakes in university undergraduates (age 19-23 years).

After giving written consent to participate, participants were asked to complete a set of questionnaires regarding their age, general health, and sleeping patterns.

Sleep questions were concerned with sleeping problems (e.g. daytime sleepiness, difficulty falling asleep, difficulty staying asleep and too little sleep measured on an ordinal scale), sleeping and waking times (measured on an interval scale).

Participants received general information about the purpose of the study and were instructed about the workings of various components of the simulator controls and about the task they were to perform during the drive. All participants were asked to drive using a fixed-base driving simulator (STISIM PC-based interactive driving simulator (model 100) housed in a Fiat Cinquencento. A 60° horizontal field of view was projected onto a large screen. The scenario consisted of a rural section, an urban section and a dual carriageway and was 8 miles in length and took about 15 minutes to complete, depending on the speed of the participants.

After a practise run, participants were asked to drive twice, once normally, with no distraction while their second run was with distractions.

The driver was distracted either by being asked to read a map, operate a radio, take a drink, open a sweet packet or discuss with the experimenter (on a mobile phone) who sat as a passenger during the drive.

The results showed that drivers had more speed limit exceedances and more road edge excursions when distracted. There were significant positive correlations between speed exceedance and obtaining too little sleep, and between feeling uncomfortable during the day in the distracted drivers. There was also a significant negative correlation between speed exceedances and actual hours of sleep. Even when not distracted, there was a positive correlation between the number of collisions and difficulty in waking up.
There was also a significant difference in speed exceedances between participants who had sufficient sleep and those that had a chronic sleep debt.

The results of this study indicate that young drivers with chronic sleep deficits are more likely to make driving errors when distracted. Also it highlights the need to probe chronic sleep habits in driving simulator experiments.

**Keywords** – distraction, sleep deficit, speed exceedances, young drivers

**References**

Normative data of simulated-based driving skills: a pilot study

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Abstract
The frequency of use of driving simulators to investigate the effects of age, alcohol, sleepiness, medication, fatigue, cardiovascular, neurological and other medical conditions on driving performance is on the increase [1; 2]. To the best of our knowledge, no normative data on driving measures commonly used in driving simulations currently exists. The main aim of the pilot study was to establish normative values for some of the simulator measures.

Methods:
Sixteen younger (18-24 yrs) and 17 middle-aged (25-64 yrs) persons who legally drove at least 10 miles per week and were considered healthy based on assessments of physical ability, mental state, visual and cognitive status participated in the pilot study.

All participants drove simulated traffic scenarios in a stationary full-sized car with automatic gear transmission system powered by STISIM Drive System Model 300 with images projected on a 9 sq. ft. screen with 50° field of view.

Participants first drove a 5-minute familiarization scenario after which a 9.5-mile program was presented. The 9.5-mile scenario simulated mid-day traffic on a chosen route around Augusta, GA that contained urban and highway traffic. Data on numbers of road excursion, centerline crossings, speed exceedances in 35, 45, 55 and 70 mph zones, failures to stop at traffic lights, off-road accidents and total run time in the 9.5 mile scenario were automatically generated in the simulator computer. Twenty-four of the participants (11 younger and 13 middle-aged) drove a 3.5 mile scenario with 45 mph speed limit specifically to assess reaction time measures and during which data on seeing, movement, and overall braking reaction time were documented.

Results:
Group-based values for younger drivers were: number of road excursions = 21 (16-28), speed exceedance at 35 mph = 1±1, at 45 mph = 2 (2-4), at 55 mph = 2±1, failures to stop at traffic lights = 1 (0-2), and total run time in seconds = 826 (787-886).

Values for the older drivers were: number of road excursions = 20 (18-24), speed exceedance at 35 mph = 2±1, at 45 mph = 2 (0-3), at 55 mph = 2±1, failures to stop at traffic lights = 1 (1-2), and total run time in seconds = 830 (772-866).
Neither younger nor middle-aged drivers crossed the centerline and exceeded the speed limit in 70 mph zones. Older drivers recorded 4 off-road accidents as compared to none in younger drivers and 3 on-road collisions were recorded for older drivers while only one was recorded for younger drivers.

In the reaction time scenario, younger drivers’ seeing time = .4±.1, movement time = .3 (.2-.4) and overall braking reaction time = 4.0 (3.6-4.3) and older drivers’ seeing time = .5±.1, movement time = .2 (.1-.2) and overall braking reaction time = 4.0 (3.4-4.0) all in seconds. Between groups comparisons for these data revealed a significant difference only in off-road accidents.

Discussion:
For most measures, the values for younger drivers were not significantly different from those of older drivers, which is probably due to the small number of participants. The pilot study is on-going and it is our intention to recruit 60 participants in each of 3 age categories: 18-24, 25-64 and 65+ to establish regression-based normative values for the simulator measures.

Keywords – driving, simulators, normative data

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