



A Survey of Challenges Related to the Design of 3D User Interfaces for Car Drivers

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The Car - A Complex 3D User Interface





Overview

- Constraints of an Automobile Environment
- Definition of Terms

- Input
- Output
- Interaction Techniques



Constraints of an Automobile Environment

- Maneuvering a car is a complex task that needs a significant amount of the driver's attention
- All secondary in-car interaction systems must be
 - Extremely user centered
 - Learnable
 - Efficient
 - Memorable
 - Interruptible
 - Non distractive
- Satisfy ISO standards
 - DIN Deutsches Institut für Normung. Road vehicles - Ergonomic aspects of transport information and control systems - Dialogue management principles and compliance procedures, Mar. 2003. Ref.No.: DIN EN ISO 15005:2003.
 - DIN Deutsches Institut für Normung. Road vehicles - Ergonomic aspects of transport information and control systems - Specifications and compliance procedures for in-vehicle visual presentation, Oct. 2003. Ref.No.: DIN EN ISO 15008:2003-10.

Interaction in Cars – Classification of Tasks

- Primary task: Maneuvering the vehicle
- **Secondary** tasks: Mandatory functionality (oil temp, turn signal)
- **Tertiary** tasks: Entertainment, comfort and information functionality

- Corresponding IO devices are placed in separate areas





Driver Information vs. Driver Assistance

- Categorization based on goals towards comfort and safety
 - IVIS: In-Vehicle Information Systems
 - ADAS: Advanced Driver Assistance Systems

- Cross-Relationships
 - IVIS \leftrightarrow Tertiary tasks
 - ADAS \leftrightarrow Primary, secondary and tertiary tasks



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Input – Primary, Secondary and Tertiary Devices

- Primary devices
 - One-to-one mapping to functionality and immediate feedback
 - Intuitive mapping: device properties (shape, degrees of freedom, associated action) ↔ 3D control of the car
- Secondary devices
 - Easy to access but not as direct as primary ones
 - Easy to understand
- Tertiary devices
 - Many functions => one-to-one mapping impossible
 - Immediate and direct access to functionality not necessary





Input – Speech and Gesture

- Speech
 - Common assumption: Speech does not use the visual channel
 - But: Speech affects the visual channel - users need a reference point
- Gesture
 - Could be used to provide alternative input to tertiary tasks
 - But: Users might require a visual or auditory channel for feedback

- T. Ranney, J. Harbluk, and I. Noy. Effects of voice technology on test track driving performance: Implications of driver distraction. In The Journal of the Human Factors and Ergonomics Society, 2005.
- U. Plangger, A. Khosravi, and G. Helas. Einfluss von sprachlicher und haptischer Bedienung auf die Fahrleistung und das Blickverhalten. Master's thesis, Technische Universität München, Chair for Ergonomics, 2005.
- F. Althoff, R. Lindl, L. Walchshäusl, and S. Hoch. Robust multimodal hand- and head gesture recognition for controlling automotive infotainment systems. In VDI: Fahrer im 21. Jahrhundert, November 2005.

Output – Visual Displays – Monitor and HUD

- Central Information Displays



- HUD

- Semi immersive approach
- Close to line of sight
- Short glance time
- Field of view around 6 degrees



Output – Visual Displays - HUD

Augmented Reality for ADAS

- Egocentric guidance of driver's attention to direction of imminent danger
- 3D navigation systems



□ DuPont. The DuPont Wedge for Head-up Display illuminates safety, navigation and handling features. http://www.dupont.com/safetyglass/en/newsEvents/hud_gm.html.

Siemens VDO

□ M. Tönnis, C. Sandor, C. Lange, G. Klinker, and H. Bubb. Experimental evaluation of an augmented reality visualization for directing a car drivers attention. In Proceedings of ISMAR, October 2005.



Output – Visual Displays - HUD

Questions and problems

- Information Overload: Too much information, too rapid changes
- Perceptual Tunneling: Focus on one stimulus by neglecting to other important tasks
- Cognitive Capture: ‚lost in thought‘ and loss of situational awareness
- Occlusion



Output – Auditory Displays

- Signals and 3D Sounds
 - Indicate immediate danger
 - Guide to a direction

- Speech
 - Feedback for tertiary tasks
 - Useful when information transfer rate is faster than via other channels
 - Not suitable for spatial and continuous information
 - Can cause attentional capture

□ J. D. Lee, J. D. Hoffman, and E. Hayes. Collision warning design to mitigate driver distraction. In Proceedings of CHI, April 2004.



Output – Haptic and Multimodal Displays

- Predestined to capture driver's attention (-> ADAS)
 - Steering wheel: Heading control
 - Gas pedal: Speed and distance control
- Tertiary tasks: Click-stops allow blind control of devices

- Multimodal displays (visual and auditive)
 - ADAS: Indication of direction to imminent dangers
 - IVIS: Parking assistant



Interaction Techniques – Manipulation, Travel

- Manipulation
 - ADAS: Joystick <-> Steering wheel and pedals
 - IVIS: Manipulation must be interruptible

- Travel
 - ADAS: Driving Task
 - IVIS: Travelling in menu structures
 - Navigation by use of multifunctional controllers or speech
 - Direct access by use of speech tokens or special buttons

- B. Spanner. Einfluss der Kompatibilität von Stellteilen auf die menschliche Zuverlässigkeit. PhD thesis, Technische Universität München, Chair for Ergonomics, 1993.
- W. Wang. Human Navigation Performance Using 6 Degree of Freedom Dynamic Viewpoint Tethering in Virtual Environments. PhD thesis, Univ. of Toronto, Mechanical and Industrial Engineering, 2004.



Interaction Techniques - Wayfinding

- ADAS
 - Currently central information display shows route
 - Research on HUD technology for wayfinding issues
- IVIS
 - Define well structured cognitive maps of the menu hierarchy
 - A 3D spatial interface for wayfinding in menus is assumed to deteriorate wayfinding/manipulation of the primary task



Interaction Techniques – System Control

- Issues:
 - ADAS: Consider suitably integrated system control techniques for ADAS systems
 - IVIS:
 - Can a network structure outperform a hierarchical menu?
 - Can browsing ease the access of functionality?

- M. Ablassmeier, G. Niedermaier, and G. Rigoll. A new approach of using network dialog structures in cars. In 8th World Multiconf. On Systemics, Cybernetics and Informatics, Orlando, USA, Jul. 2004.



Interaction Techniques – Symbolic Input

- Modern infotainment systems require symbolic input (navigation destination, phone number, ...)
- Currently multifunctional controllers allow to select individual letters
- Extensions/Alternatives
 - Keyboards of mobile phones (T9)
 - Handwriting recognition on touchpads
 - Speech recognition



Conclusion and Findings

- Overview about the potential and the problems involved in bringing 3D user interfaces and interaction into automotive driving environments
- A special case: A task of high priority – driving the car
- Findings
 - HUD seem to have a promising potential for ADAS
 - Interaction is mainly manipulation, travelling and wayfinding – these must be kept as simple as possible
- Our Future Work
 - Explore HUD technology
 - Explore depth based graphical information presentation



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