Gestures and Speech in Cars

Ulrich Reissner
reissner@in.tum.de

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Department of Informatics | Technische Universität München

Overview

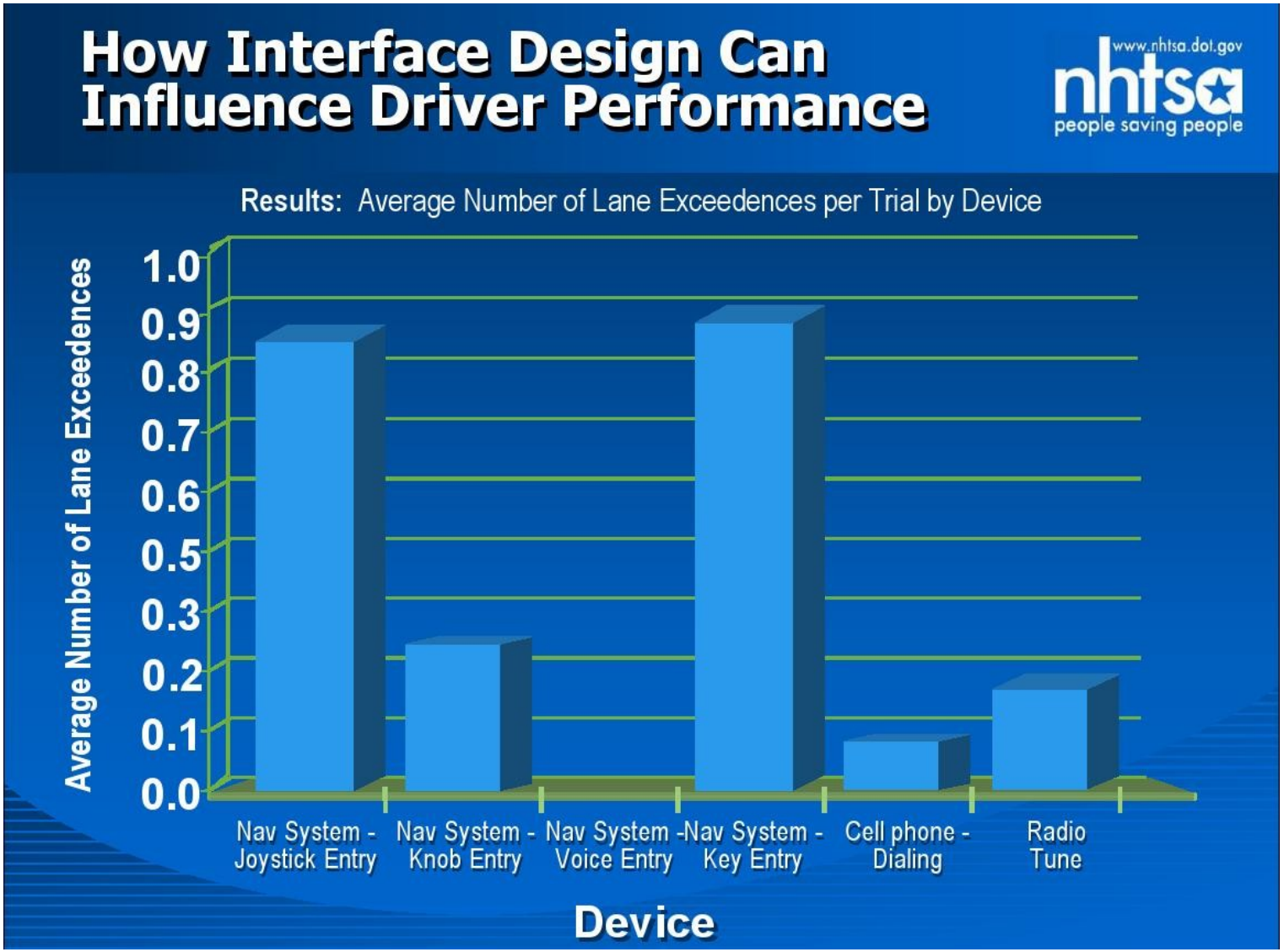
- Driver Distraction
- Evolution of Human-Computer-Interfaces

- Sound and Speech
- Head and Hand Gestures
- Multimodal Human-Computer-Interfaces

Driver Distraction

- Types of distraction
  - Perceptual Tunneling, Cognitive Capture
  - Lack of concentration
  - Outside events
  - Use of Information and Entertainment (Infotainment) systems

Joseph N. Kanianthra; National Highway Traffic Safety Administration; Driver Distraction: Understanding the Problem, indetifying solutions; CES 2005



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Driver Distraction

- Influence of interface design
- Cause for up to 40 percent of car accidents

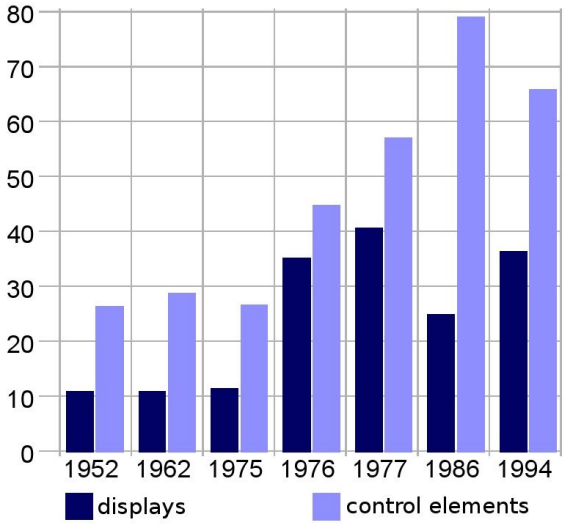
- well designed HCIs
  - easy, intuitive use
  - reduce driver distraction

Joseph N. Kanianthra; National Highway Traffic Safety Administration; Driver Distraction: Understanding the Problem, indetifying solutions; CES 2005

Evoltution of Human-Machine-Interfaces

- increased number of devices
- different suppliers

- new concepts
  - integrated operation concept: Multfunctional Controllers
    - iDrive - BMW
    - MMI – Audi
  - gestures and speech



• M. Geiger. Berührungslose Bedienung von Infotainment-Systemen im Fahrzeug. PhD Thesis, TU München, 2003.

Overview

- Driver Distraction
- Evolution of Human-Computer-Interfaces

- Sound and Speech
  - Input
  - Output

- Head and Hand Gestures
- Multimodal Human-Computer-Interfaces

Speech Input

- Alternative to commonly used haptical input

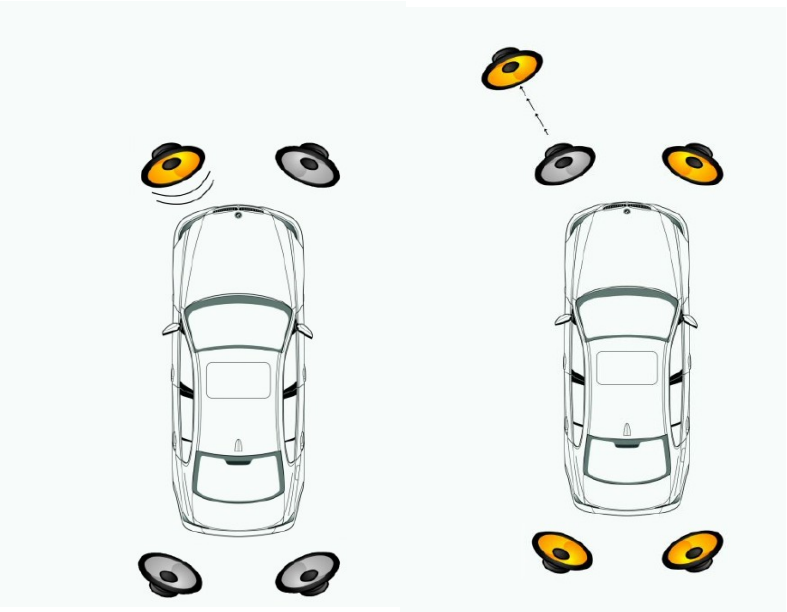
- common assumption : Speech does not use the visual channel
- But: Speech affects the visual channel
  - users need a reference point
  - users need feedback

- Problems:
  - speech recognition
  - segmentation
  - noisy environment

• 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 Egronomics, 2005.
• D.A. Bowmann, E. Kruijff, J.J. LaViola, and I.Poupyrev. 3D User Interfaces: Theory and Practice. Addison Wesley, 2004.

Sound Output

- reduce load on visual channel
- Signals and 3D Sound
  - Indicate immediate danger
  - Guide to a direction
  - Feedback for infotainment systems
- BMW Park Distance Control (PDC)



Speech Output

- Also feedback for infotainment systems
- Usefull when information transfer rate is faster than via other channels
- Not suitable for spatial and continuous information
- Can cause cognitive capture and perceptual tunneling

•Marcus Tönnis, Verena Broy, and Gudrun Klinker. A Survey of Challenges Related to the Design of 3D User Interfaces for Car Drivers. In Proceedings of the 1st IEEE Symposium on 3D User Interfaces (3D UI), mar 2006.

Overview

- Driver Distraction
- Evolution of Human-Computer-Interfaces
- Sound and Speech

- Head and Hand Gestures
  - Pilot Survey
  - Types of Gestures
  - Application Scenarios
  - Implementation Examples
  - Evaluation

- Multimodal Human-Computer-Interfaces

Gestures

- alternative to existing input modalities
- Many gestures are used to transfer information

- Questions to be answered before integrating gestures
  - How intuitive is gesture?
  - How good is the user acceptance?
  - How gesture operation can be influenced by design of Human-Computer-Interface?

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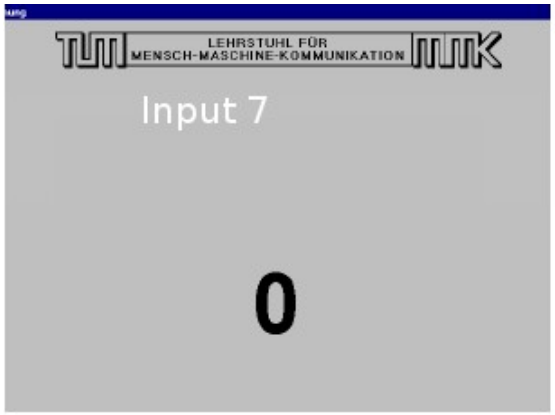
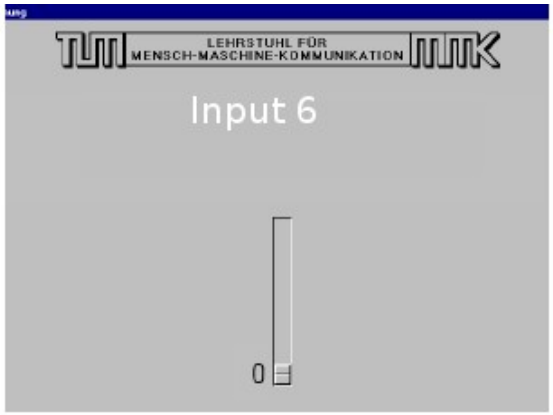
Gestures – pilot survey

- no automotive environment
- users
  - no defined gesture vocabulary
  - free to choose kind of gesture
  - only one hand
- operator
  - introduce users
  - monitors user
  - data glove with 3d tracker
  - manage tasks

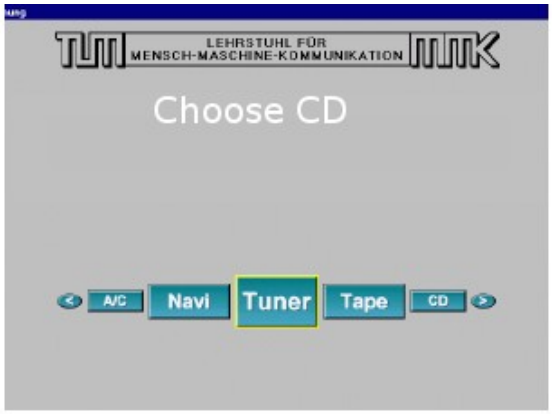
Gestures – pilot survey tasks



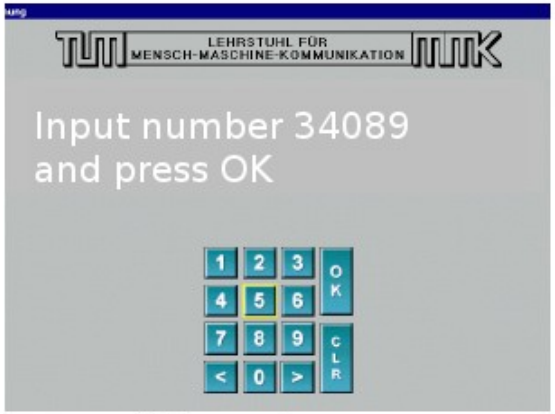
without graphical element



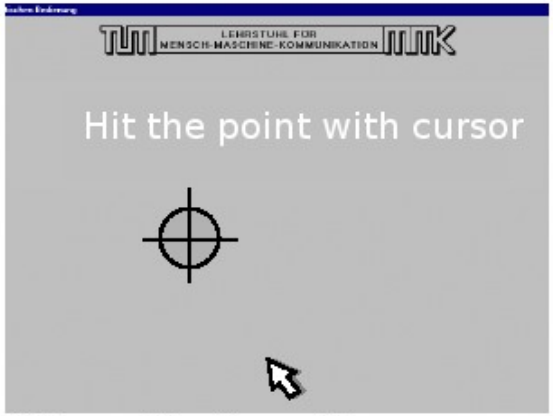
vertical slider



horizontal menu



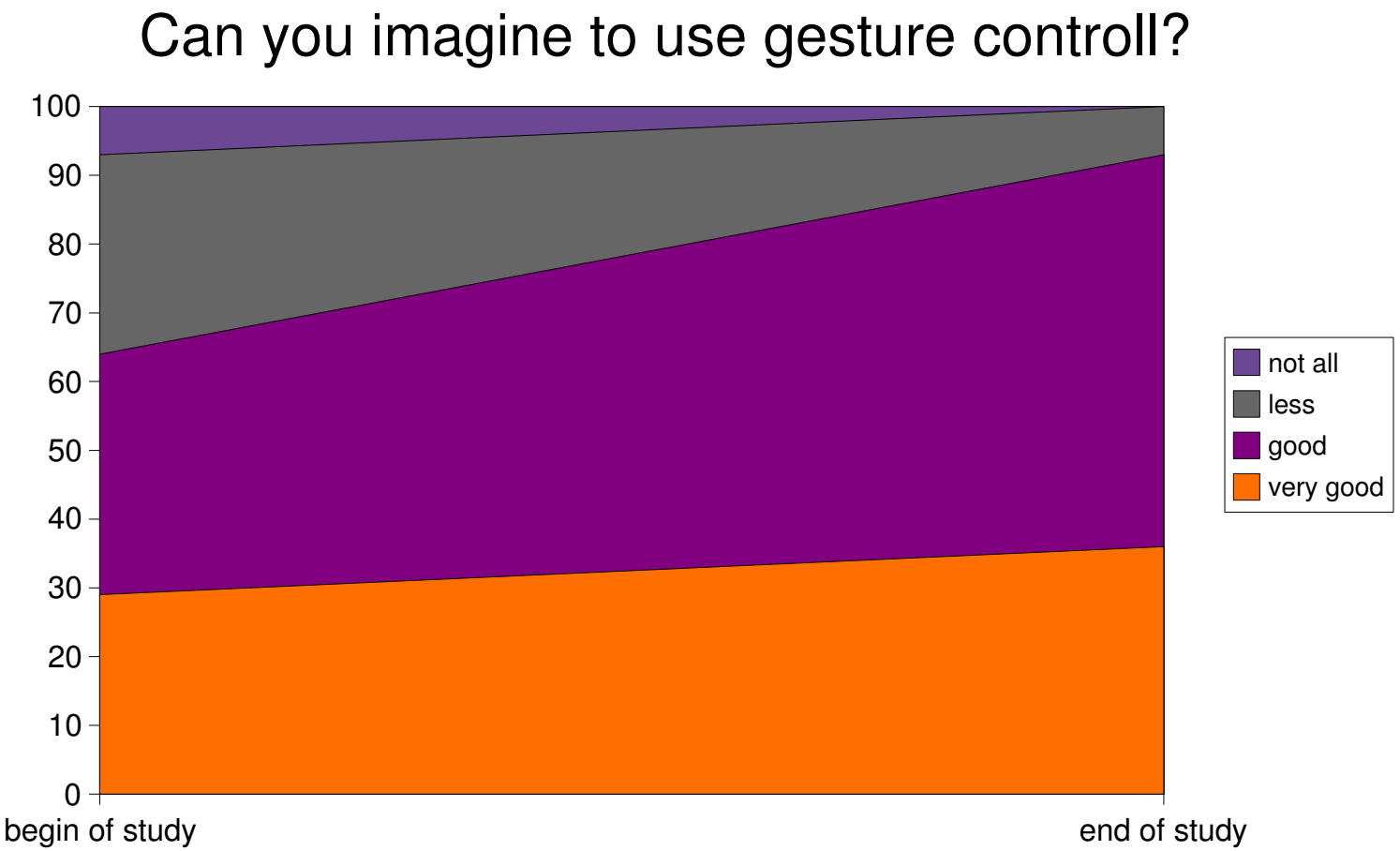
2D numbers



2D positioning with cursor

3D object manipulation

Gestures – pilot survey results

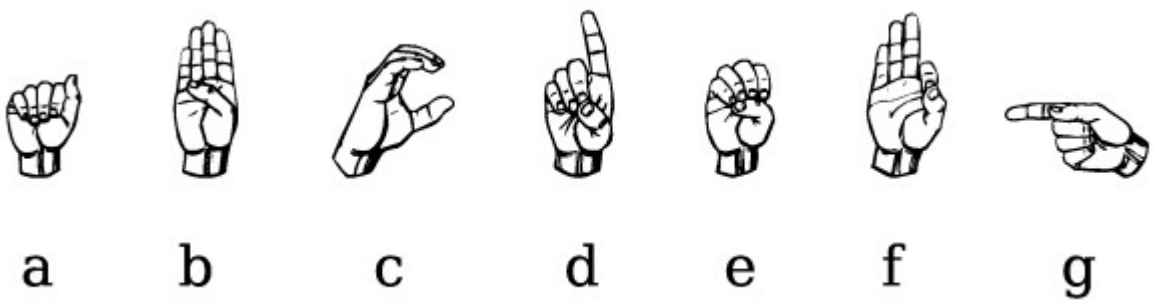


Gestures – pilot survey

- Questions to be answered before integrating gestures
  - How intuitive is gesture?
  - How good is the user acceptance?
  - How gesture operation can be influenced by design of Human-Machine-Interface?

Types of Gestures

- secondary gestures : main purpose is not communication of information
- primary gestures: only used to communicate
  - full body gestures: complete body is used
  - partial body gestures: limbs movement
  - dynamic gestures: information is in the motion sequence
  - static gestures: shaping of a body part



• M. Geiger. Berürungslose Bedienung von Infotainment-Systemen im Fahrzeug. PhD thesis, TU MÜnchen, 2003.
• American manual alphabet. http://de.wikipedia.org/wiki/Fingeralphabet.

Dynamic Partial Body Gestures

- mostly used in user studies
- natural mode of communication

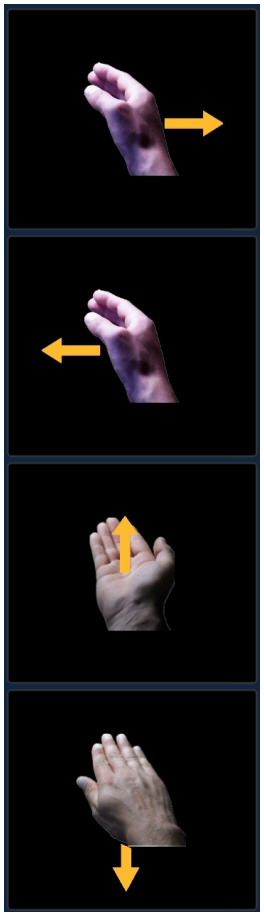
- discrete dynamic gestures:
  - closed motion sequence
  - causes one specific system reaction

- continuous dynamic gestures
  - information is in moving direction and amplitude
  - changes system status on the fly

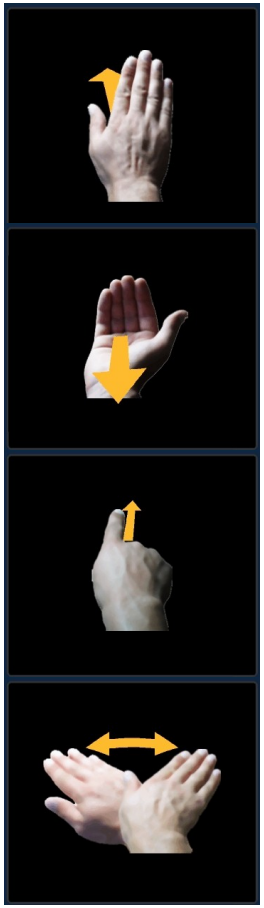
Gestures – Application Scenarios

- head gestures:
  - recognition of nodding and shaking
  - yes / no decision
- hand gestures:
  - Navigation
  - shortcut functions
  - continuous functions

Discrete Hand Gestures



1. next menu point
   move object right
2. last menu point
   move object left
3. increase volume
   move object up
4. reduce volume
   move object down



5. downsize object
6. enlarge object
7. choose actual menu point
8. mute volume
   abort function

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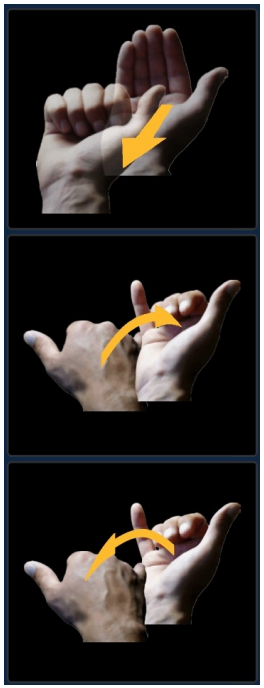
Discrete and Continuous Hand Gestures

- discrete hand gestures

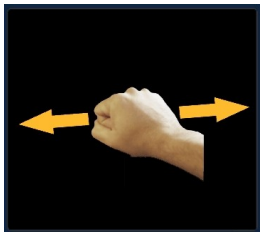


9. main menu

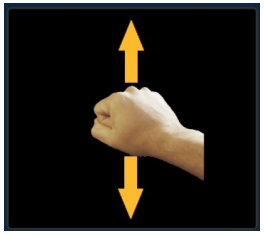
10. telephone menu
    - call a person
    - accept call

11. end call
    - denie call

- continuous hand gestures



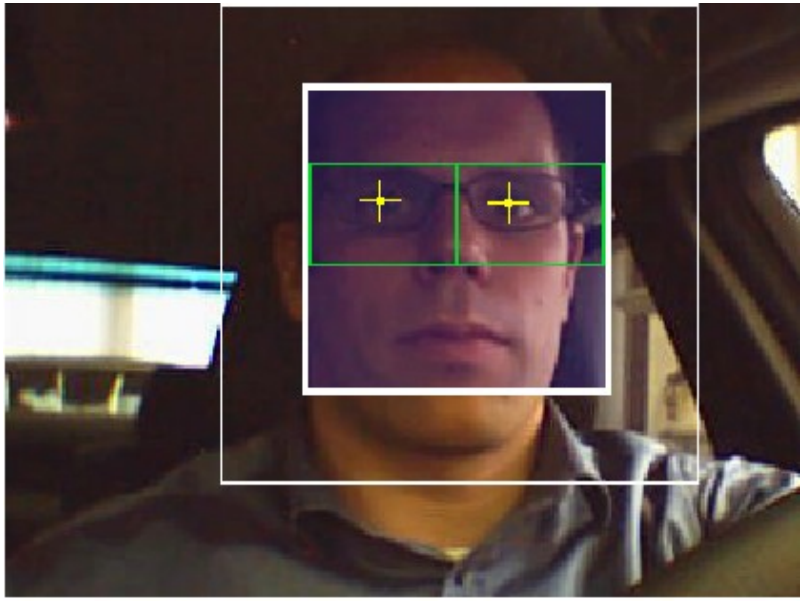
- move cursor horizontal
- move object horizontal



- move object vertical
- adjust volume

Camera based Head Gesture Recognition

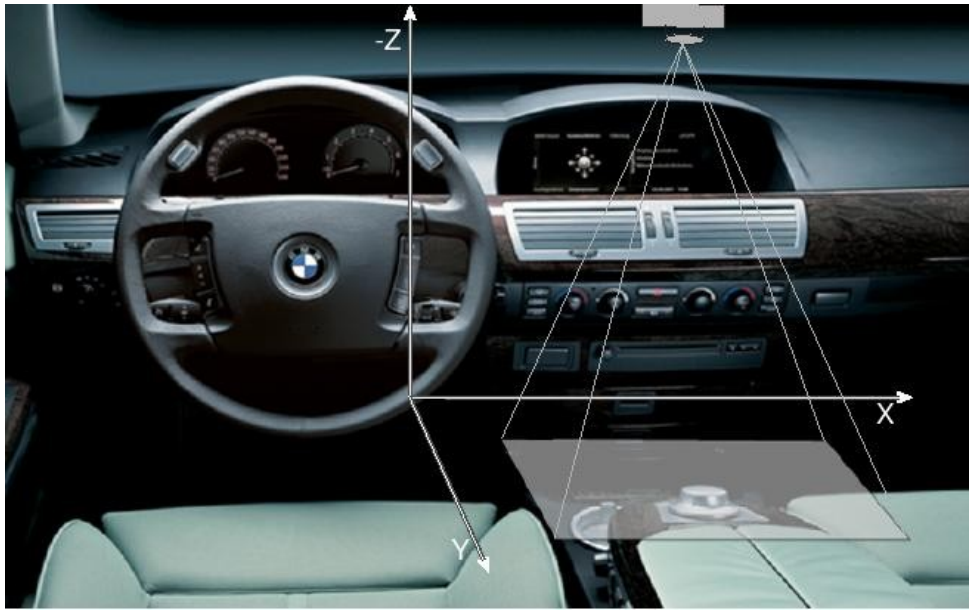
- form-based segmentation
- initial head extraction on whole image
- further head extraction on last position
- eye position on the upper half



•[14] F. Althoff, R. Lindl, and L. Walchshaeusl. Robust multimodal hand- and head gesturerecognition for controlling automotive infotainment systems. In VDI-Tagung: Der Fahrer im 21. Jahrhundert, Braunschweig, Germany, November 22-23 2005.

Camera based Hand Gesture Recognition

- near infrared imaging approach
- motion based technique instead of threshold operations



Camera based Hand Gesture Recognition

(a) (b) (c) (d) (e)

(a) IR camera image

(b) difference image

(c) entropy image

(d) binarized entropy image

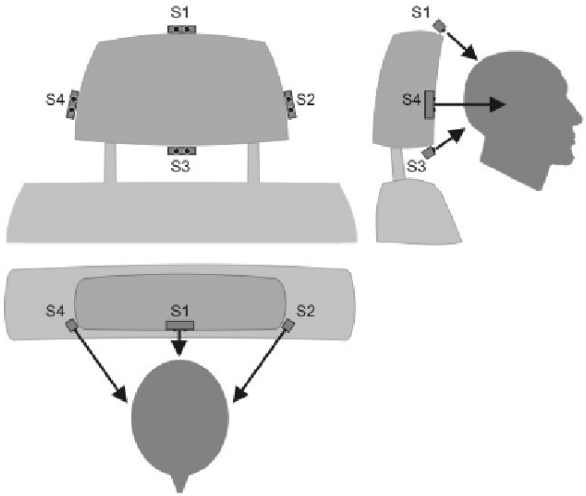
(e) result after geometrical forearm filtering

Camera based Hand Gesture Recognition

- Hidden Markov Models are used to classify gestures
- gestures are limited to relevant data
  - motion sequence
  - velocity
  - hand form
- compared with a trained stochastic model

Distance Sensor based Gesture Recognition

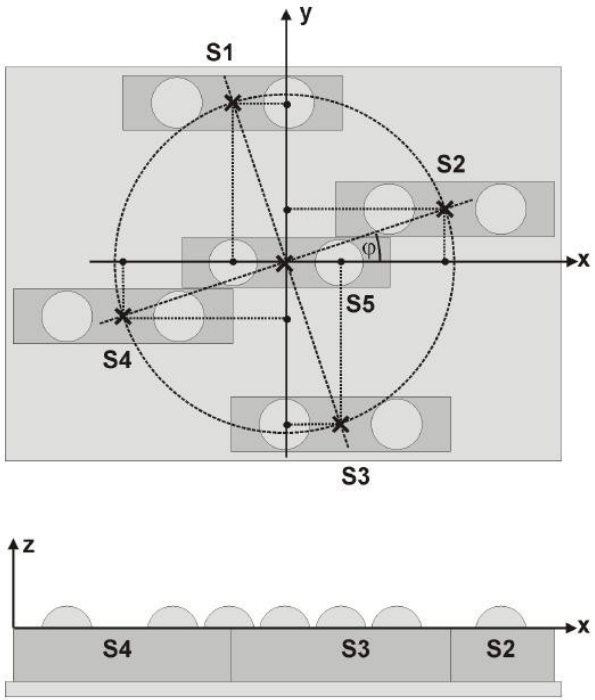
- infrared distance sensors
- head recognition
  - 4 distance sensors
  - optimized for
    - nodding
    - shaking



• M. Geiger. Berührungslose Bedienung von Infotainment-Systemen im Fahrzeug. PhD thesis, TU München, 2003.

Distance Sensor based Gesture Recognition

- Sensor S1 to S4 for horizontal hand movements
- S5 for vertical hand movements



Distance Sensor based Gesture Recognition

- Start end End of Movement are detected
- Gestures with same meaning can need different time
- motion sequence sent to Classification
- Classification with the Dynamic Time Warping Algorithm

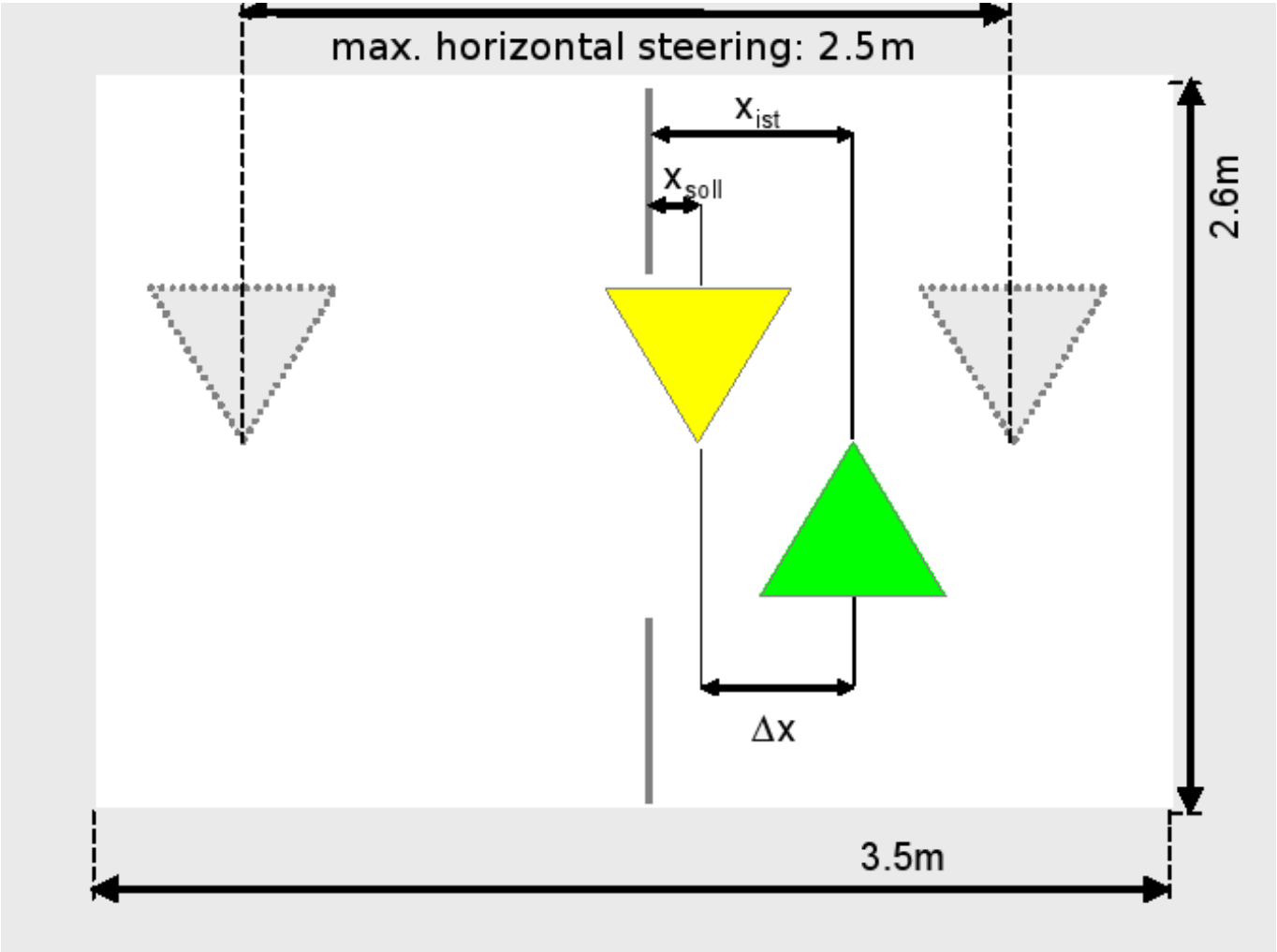
- Gesture with best match is taken

Distance Sensor based Gesture Recognition

- lower resolution than video based systems ->
  shaping of the hand can not be used

- highly robust
- low computing power
- simple sensor hardware

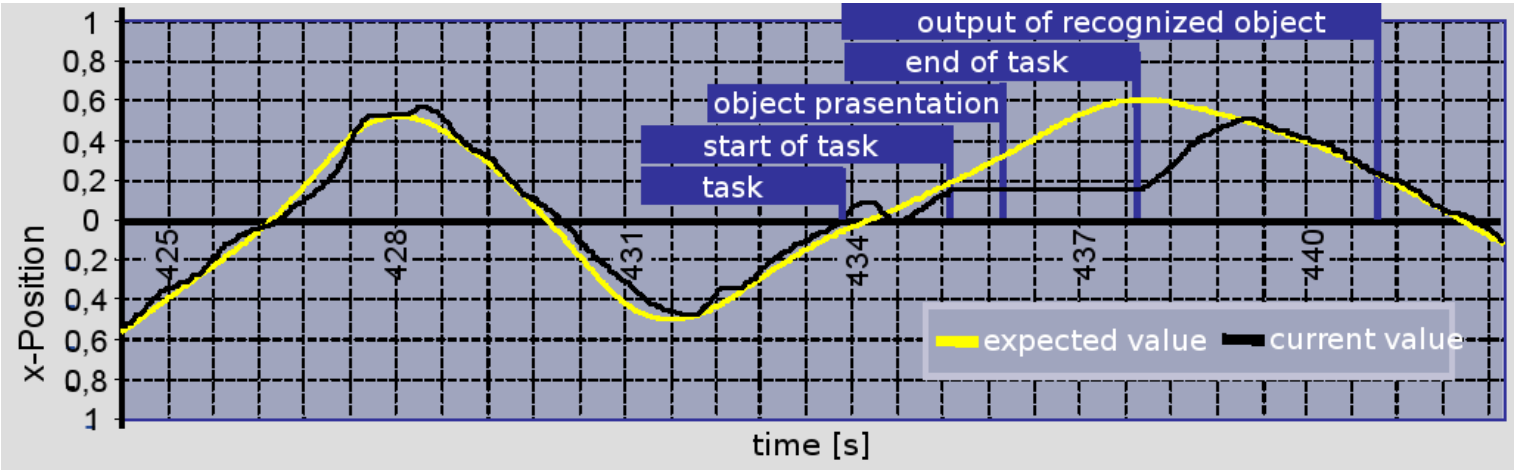
Evaluation of Gesture Recognition



• M. Geiger. Berürungslose Bedienung von Infotainment-Systemen im Fahrzeug. PhD thesis, TU MÜnchen, 2003.

Evaluation of Gesture Recognition

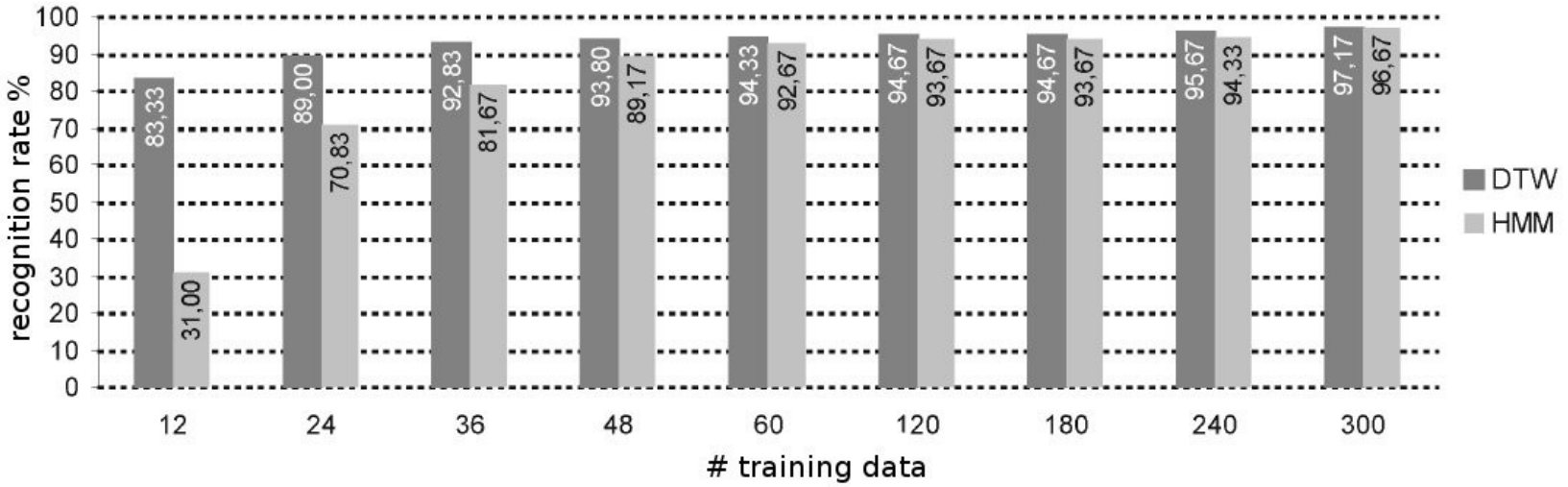
- operator presents task
- user start task
- extra object is presented
- user ends task
- operator asked for extra object



Evaluation of Gesture Recognition

- haptical <-> gesture input
- Results
  - haptical
    - longer input time
    - more steering faults
    - more faults in object recognition
- subjective Feelings
  - gesture is less distracting
  - gesture is more intuitive

Evaluation of Gesture Recognition



- recognition rates around 95%
- Hidden Markov Models needs larger trainings

- driver less distracted by gesture input than by haptic input

Overview

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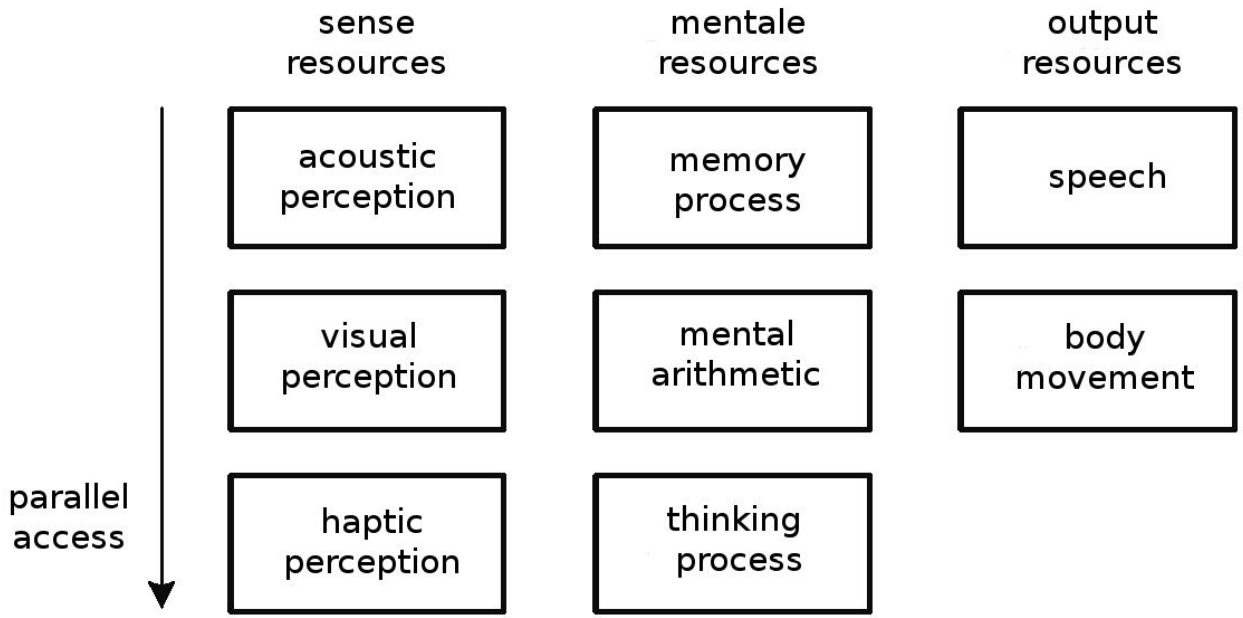
- Multimodal Human-Computer-Interfaces

Multimodal Human-Computer-Interfaces

- combine the advatages of different modalities
- multimedia output already used



• C.D. Wickens. Engineering Psychology and Human Performance (2nd Edition). Harper Collins, New York, 1992.

Summary

- gestures and speech increase
  - driving safety
  - usabilty of complex driver information system
- speech best for compact complex instructions and absolute information
- advantages of gestures
  - noisy environments
  - menu navigation
  - analog settings
  - yes / no decission

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