Driver‘s Pathway Anticipation

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Overview

- Why *pathway anticipation*
- Related work (navy and aircraft)
- Current research and implementations in car industry
  - Levels of automation
    - Adaptive Cruise Control (ACC)
    - Active Gas Pedal (AGP)
  - Head-Up Displays (HUDs)
    - design
    - evaluation
- Summary

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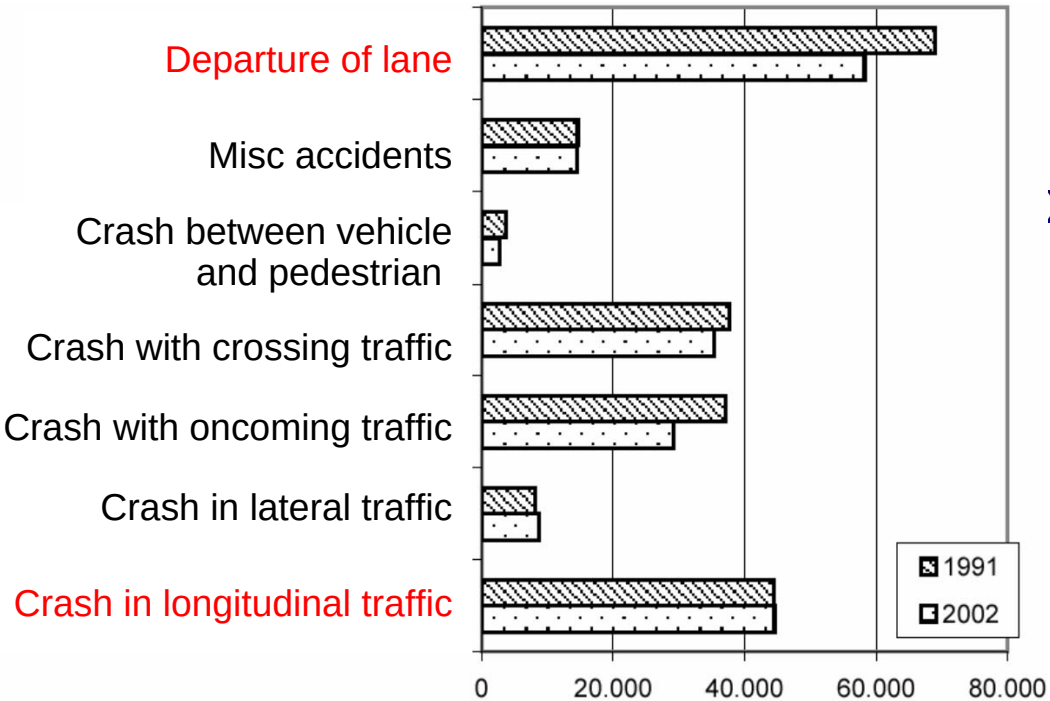
Why *pathway anticipation*



Adapted from „Statistisches Bundesamt. Unfallgeschehen im Strassenverkehr 2002“, DeStatis, 2002.

- … statistics:

X% of all car accidents are caused by *rear-end collisions* or *lane departures*

- an early solution: Adaptive Cruise Control (ACC)
  - *replace* instead of *assist* the driver
  - bad time-critical behavior (*“out-of-the-loop”*)

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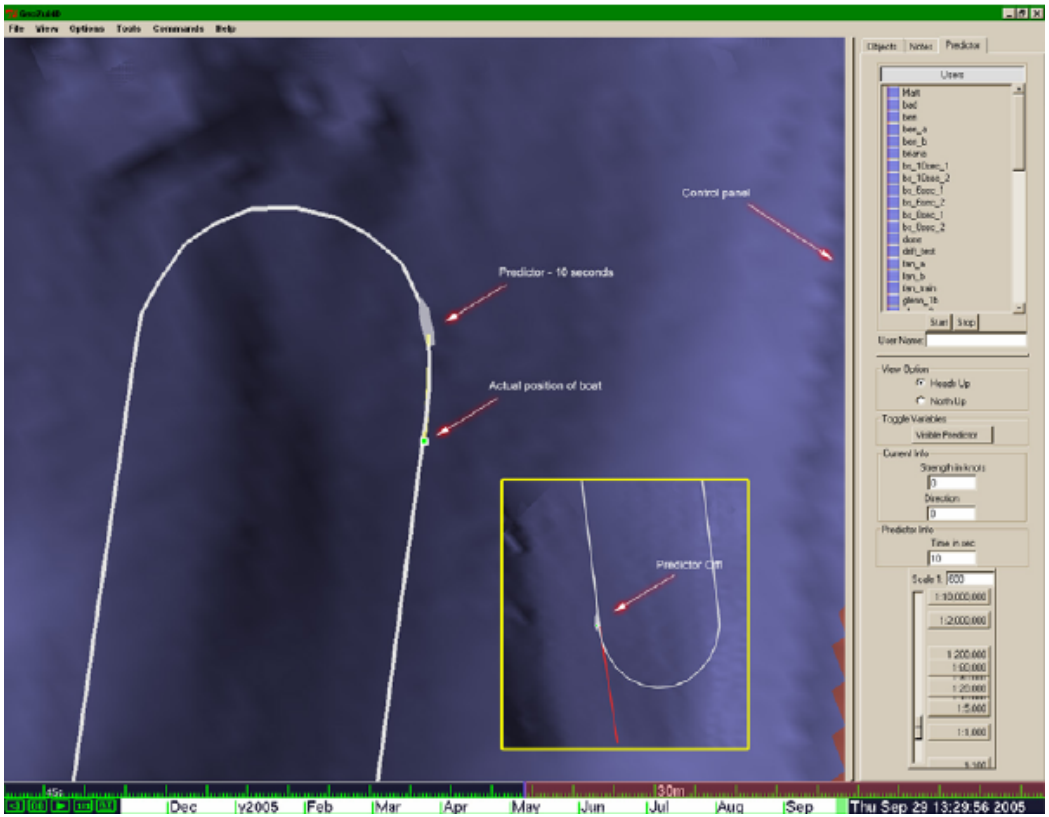
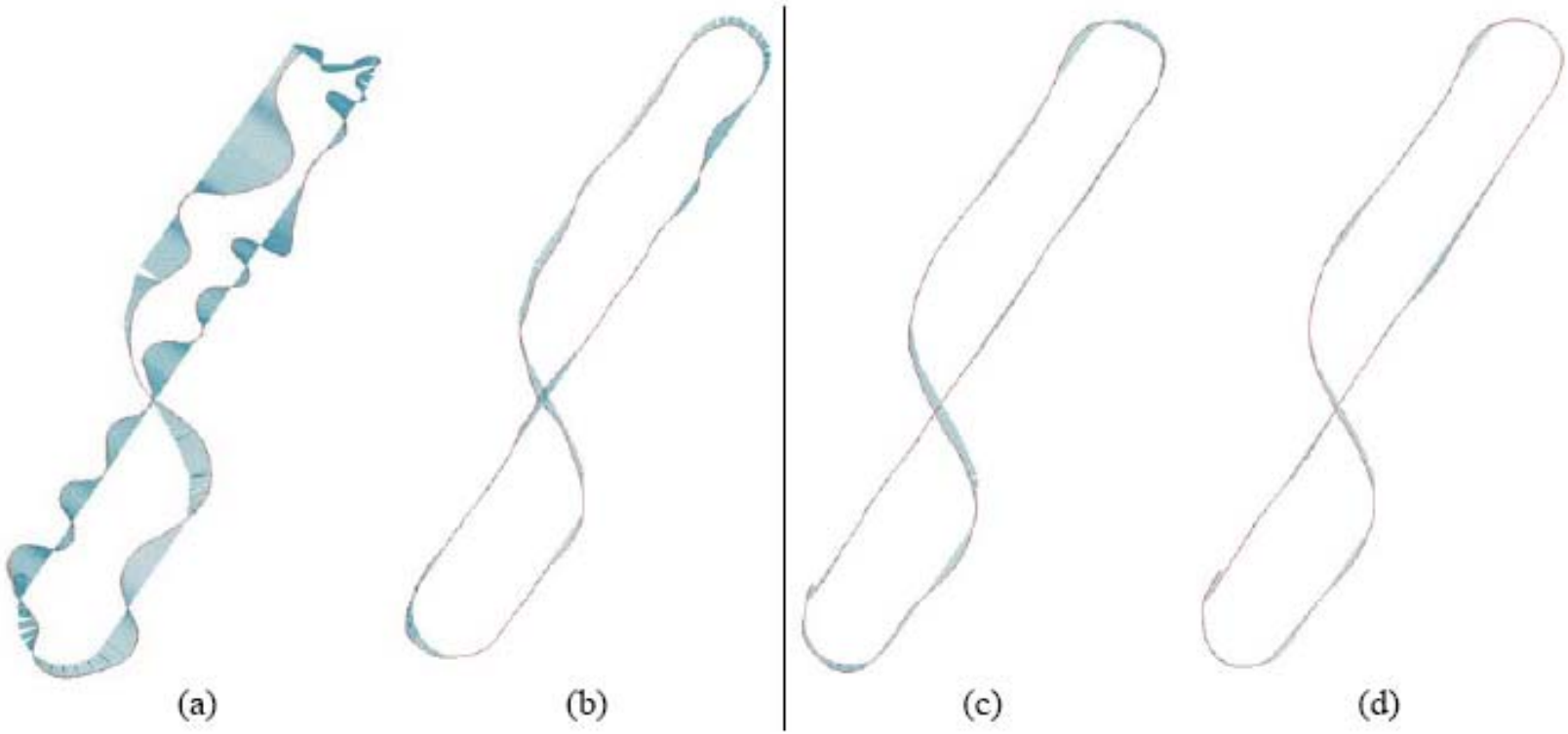
Related work in navy



- 2D movement
- delayed response
- good results

Source: „Predictive Displays for Survey Vessels“, Sullivan et. al (year 2006), HFES Proceedings

Related work in navy - results

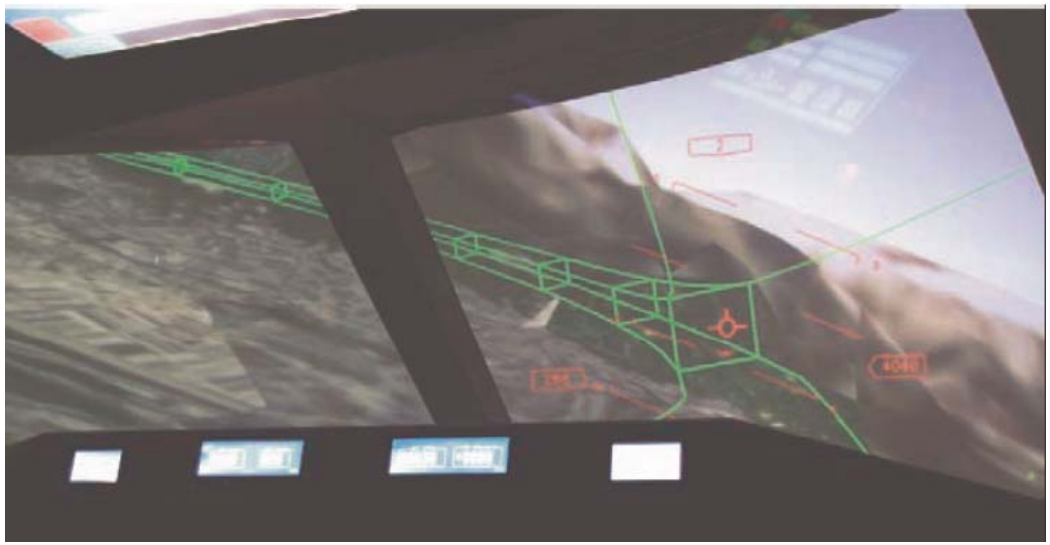


Novice participant. Predictor (a) OFF and (b) ON

Experienced participant. Predictor (c) OFF and (d) ON

Source: „Predictive Displays for Survey Vessels“, Sullivan et. al (year 2006), HFES Proceedings

Related work in aircraft



Source: „Transfer of flight-Tunnel-Presentations into the Head-Up Displays of cars“, Tönnis et. al (2006)

- 3D movement
- very high speeds
- low traffic
- „no surrounding world“

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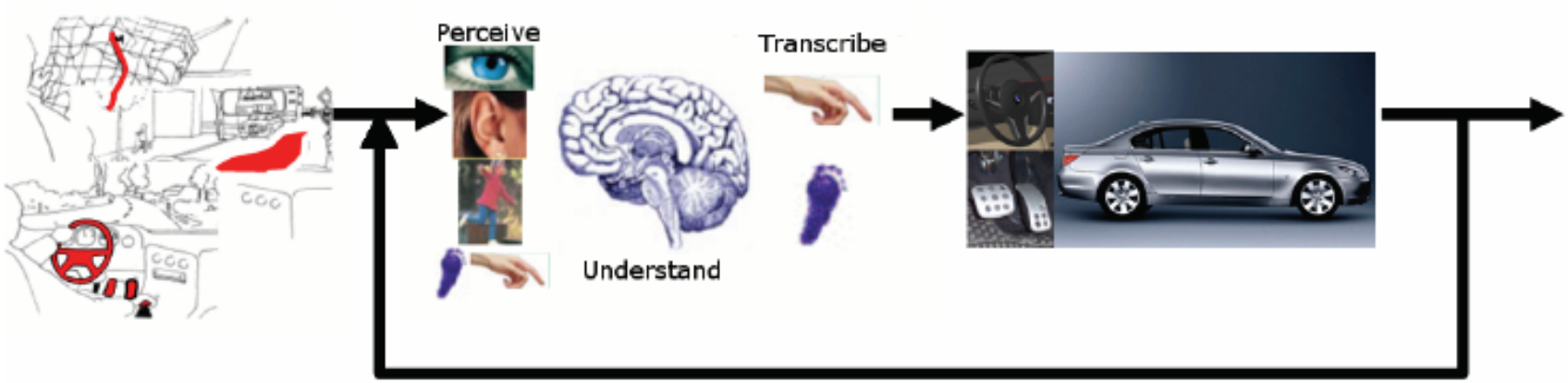
Car industry – levels of automation

- Driving loop

perception -> interpretation -> reaction (steering)

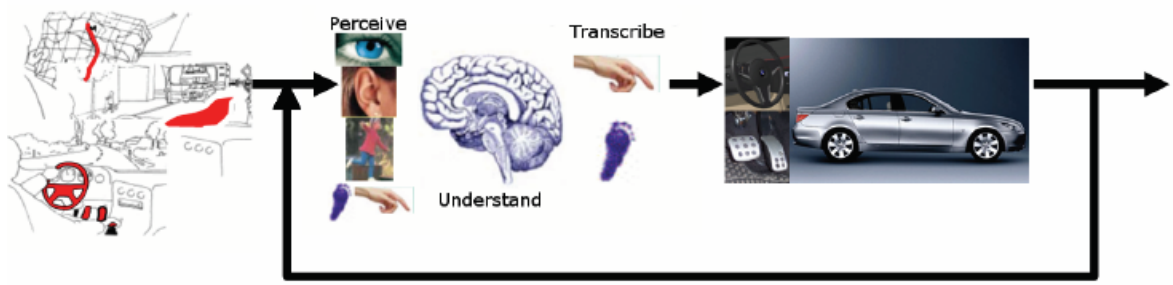


Source: „ Integration of a Component Based Driving Simulator and Design of Experiments on Multimodal Driver Assistance “, Darya Popiv (2007)

- „*in-the-loop*“ and „*out-of-the-loop*“ concepts

Car industry – levels of automation

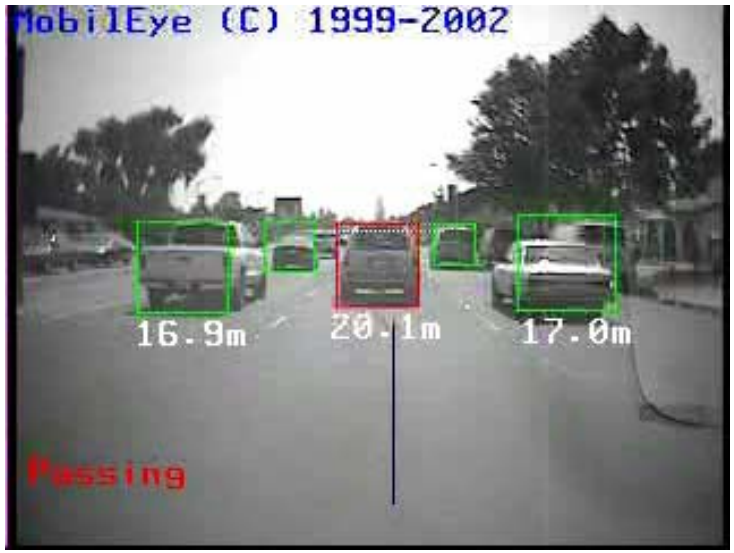
Cooperation modes:



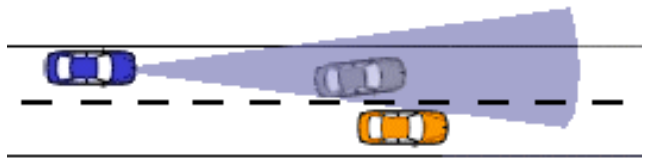
1. perceptive
2. mutual control
    - 2.1. warning stage
    - 2.2. action suggestion stage
    - 2.3. limit stage
    - 2.4. correction stage
3. functional delegation
4. fully automatic

Car industry – Adaptive Cruise Control (ACC)

- functional delegation cooperation mode -„*out-of-the-loop*
- ACC Settings:
  - *wanted speed* and
  - *desired following distance* (in sec)



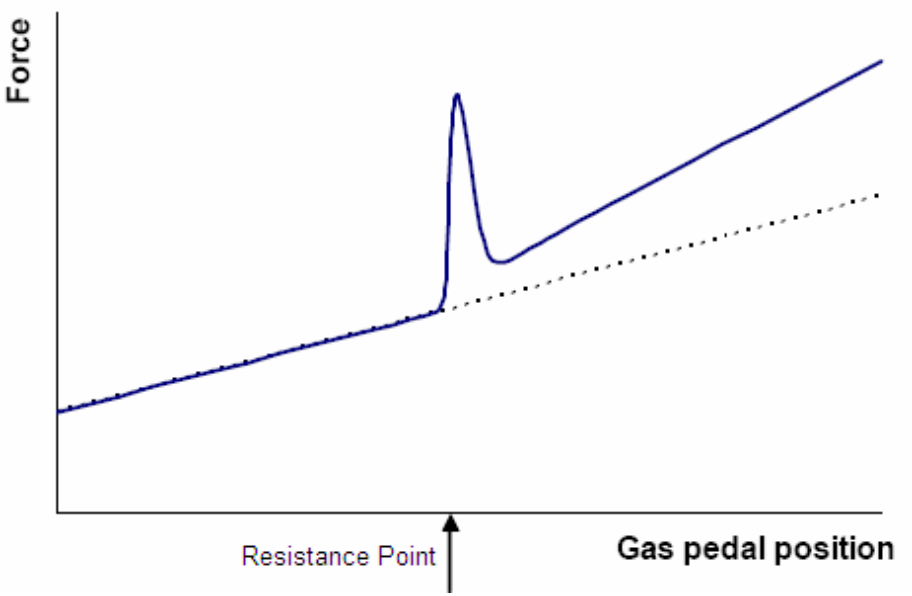
- critical point: *cut-in* situations
  - warning
  - takeover



Courtesy of BMWWorld

Car industry – Active Gas Pedal (AGP)

- mutual control cooperation mode - „*in-the-loop*“



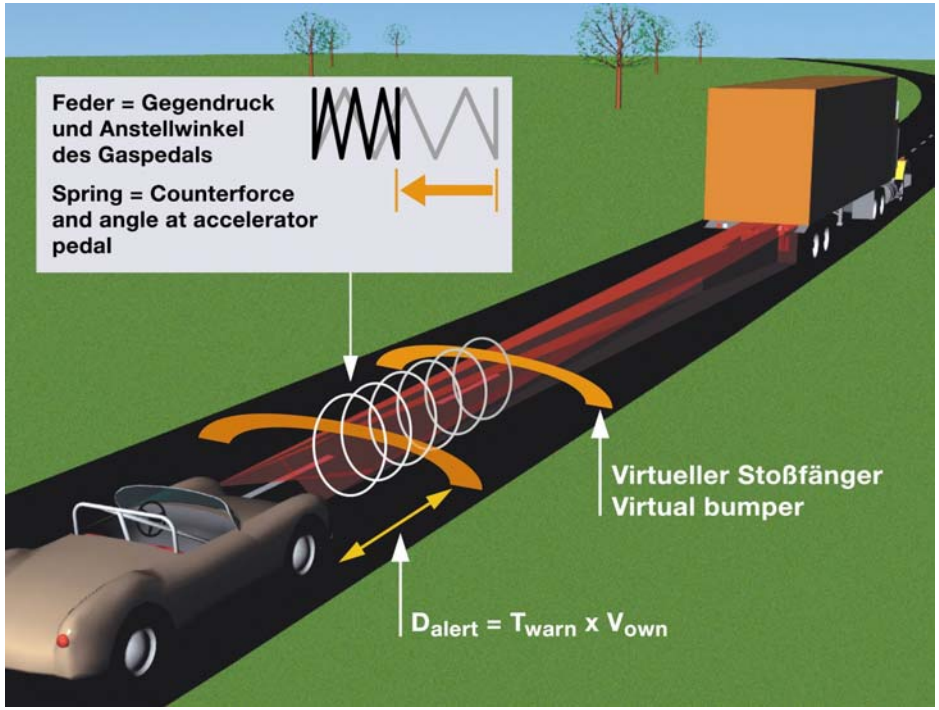
haptical signals:

- resistance point
- active force feedback or vibration

Source: „ Integration of a Component Based Driving Simulator and Design of Experiments on Multimodal Driver Assistance “, Darya Popiv (2007)

Car industry – Active Gas Pedal (AGP)

- mutual control cooperation mode - „*in-the-loop*“



haptical signals:

- resistance point
- active force feedback or vibration

“Take your foot off the gas and get ready to brake.”

Continental Automotive System, Press Release, Nuremberg November 2004

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Head-Up Displays

- another „in-the-loop“ implementation
  - visual signaling
  - the symbols representing the car state are mirrored directly on the windshield (at a fixed position)

- design issues
  - color: orange, green
  - location

- *regular(2D symbolic)* and *conformal(3D)* displays

Pictures courtesy of BMWWorld and www.webshots.com

Head-Up Displays

- Regular (2D Symbolic)

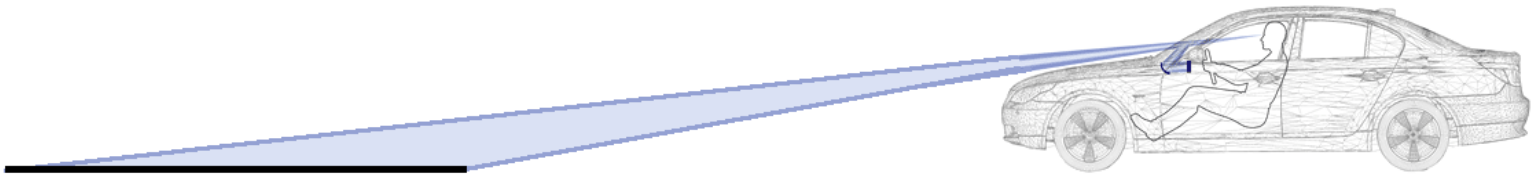
wanted speed

desired following distance

Source: „Effect of active cruise control design on glance behaviour and driving performance “Tönnis 2006

Head-Up Displays

- Conformal (3D)



the image plane lies on the street => **capable to provide depth information**

Source: “Transfer of Flight-Tunnel-Presentations into the Head-Up Display of Cars”, Tönnis (2006)

3D Head-Up Displays - design

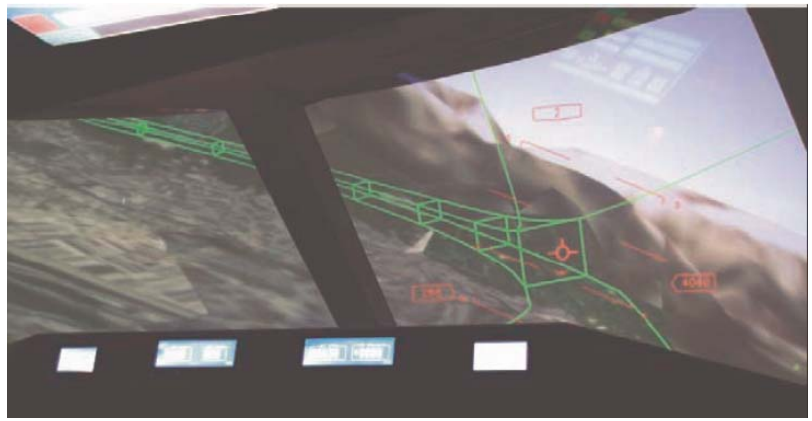
from aircraft

3D movement

↓

2D movement

to car



3D Head-Up Displays - design

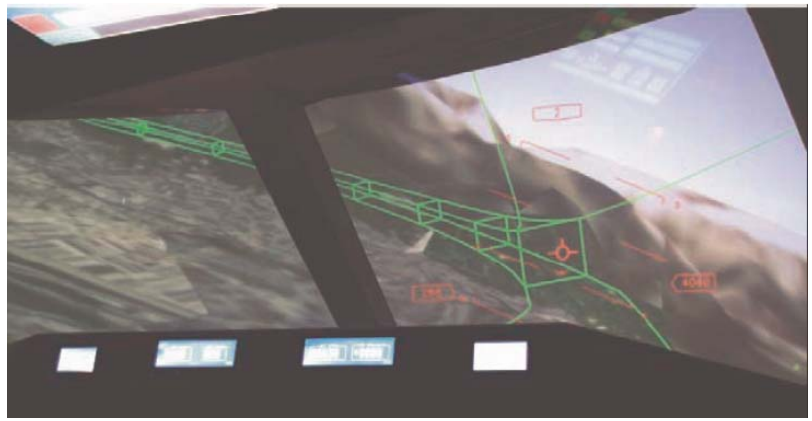
3D movement

from aircraft

high speed

low speed

to car

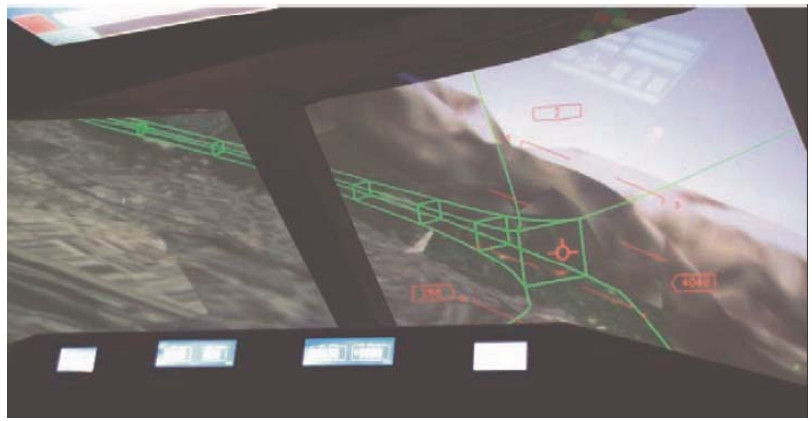


2D movement

3D Head-Up Displays - design

from aircraft

3D movement
high speed



no stop position

↓

stop position

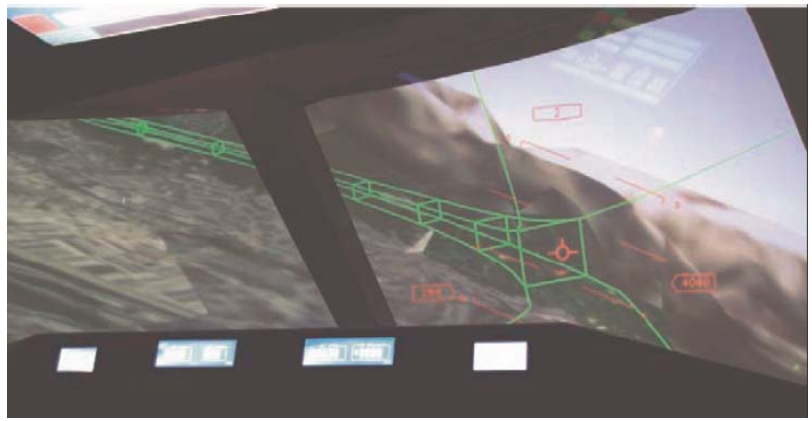
to car

low speed
2D movement

3D Head-Up Displays - design

from aircraft

3D movement
high speed
no stop position



very sparse traffic
no obstacles

↓

dense traffic
obstacles

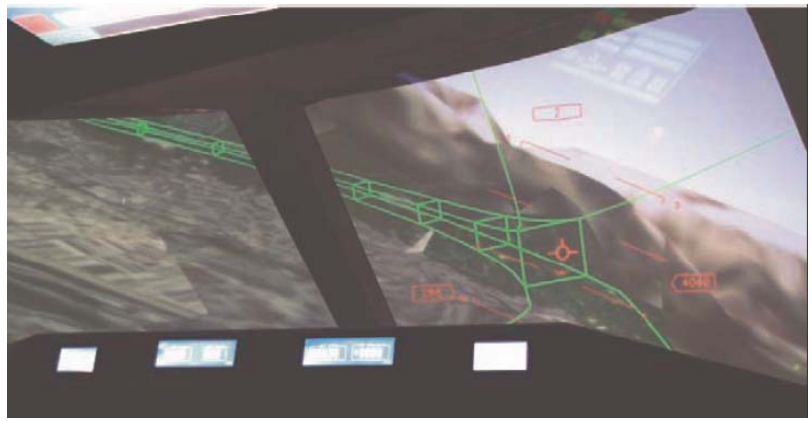
to car

stop position
low speed
2D movement

3D Head-Up Displays - design

from aircraft

3D movement
high speed
no stop position
sparse traffic no obstacles



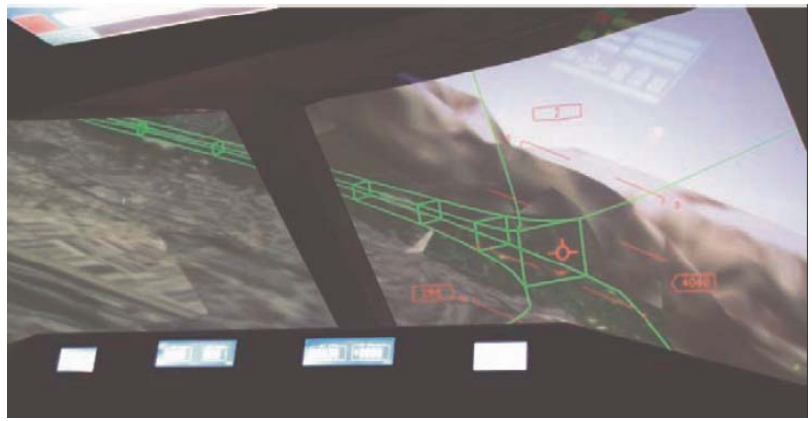
dense traffic, obstacles
stop position
low speed
2D movement

to car

3D Head-Up Displays - design

from aircraft

3D movement
high speed
no stop position
sparse traffic no obstacles



embedding space

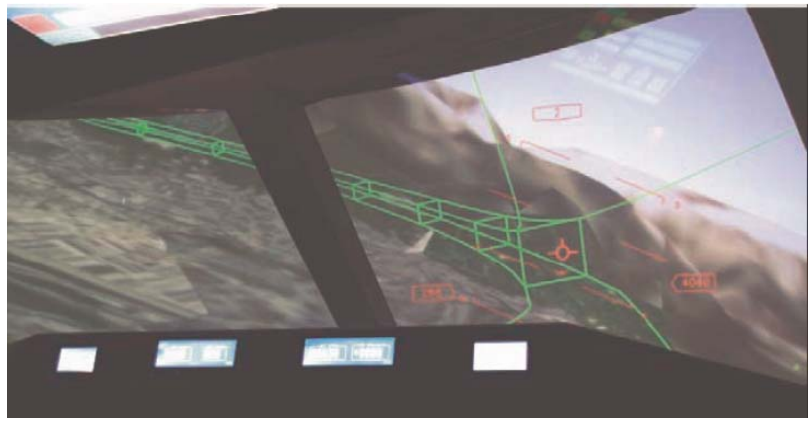
dense traffic, obstacles
stop position
low speed
2D movement

to car

3D Head-Up Displays - design

from aircraft

3D movement
high speed
no stop position
sparse traffic no obstacles



embedding space

perception tunneling
cognitive capture

dense traffic, obstacles
stop position
low speed
2D movement

to car

3D Head-Up Displays - design

- Breaking bar behaviour

speed changing

front car following mode

Courtesy of TUM, Tönnis 2007

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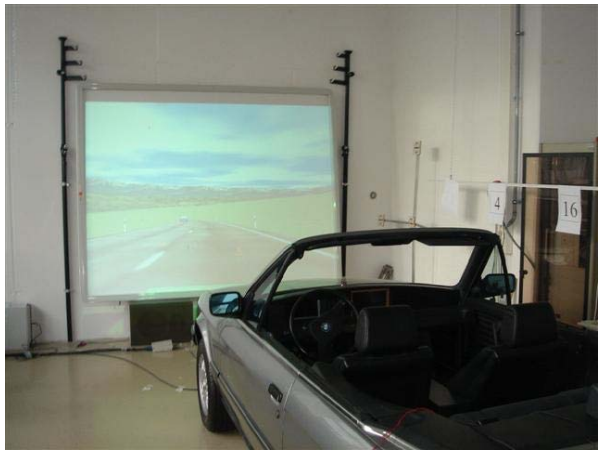
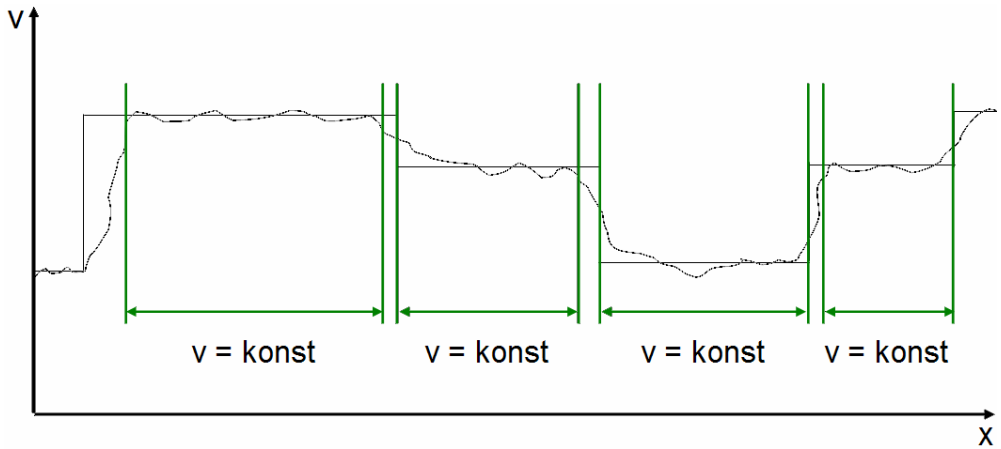
3D Head-Up Displays – evaluation

- Experiment place: driving simulator





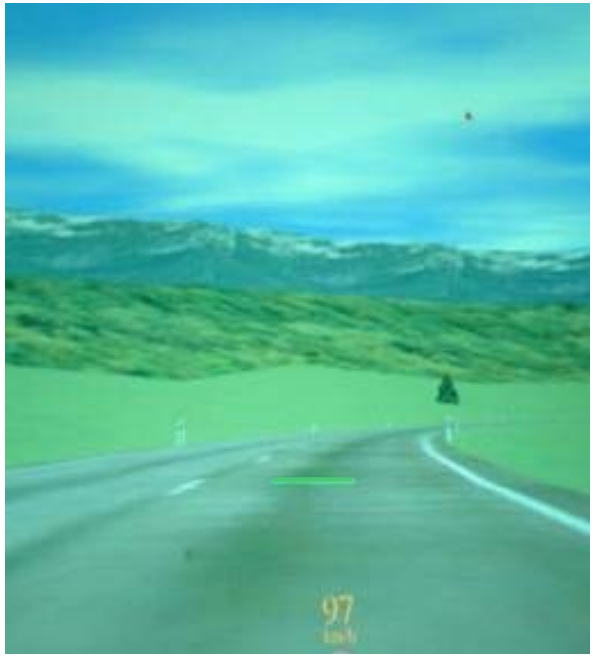
  - simulated path

3D Head-Up Displays – evaluation

- Tested options

No assistance

Breaking bar



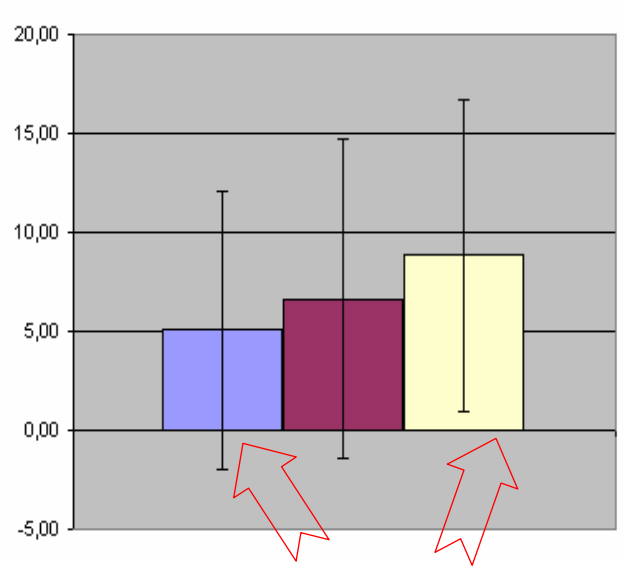
Breaking bar & drive-path

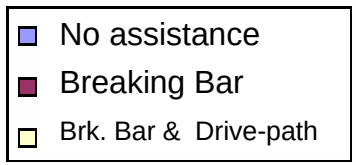
3D Head-Up Displays – evaluation

- Objective measurements

Longitudinal assistance

Difference to allowed speed

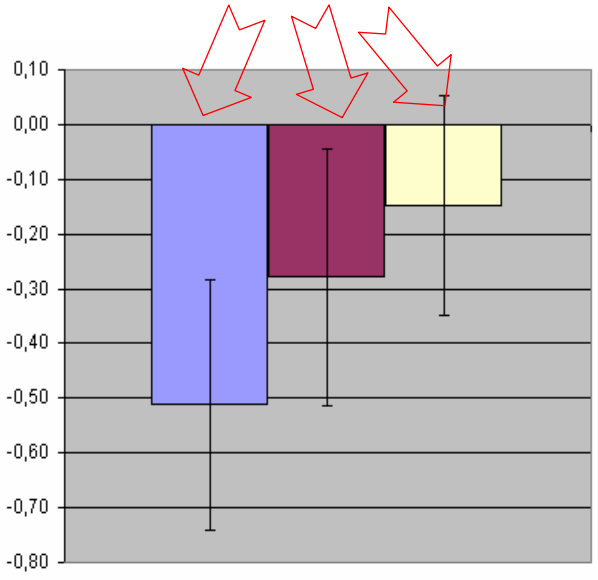




=> drive faster with visual assistance

Lateral assistance

Lane departure

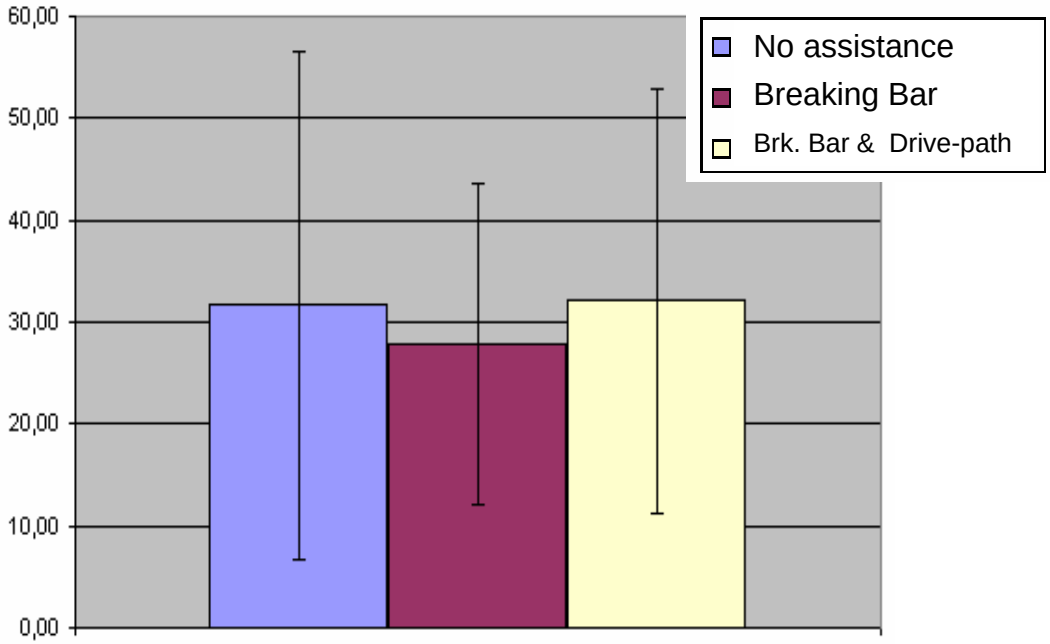


=> with visual assistance, better track keeping

3D Head-Up Displays – evaluation

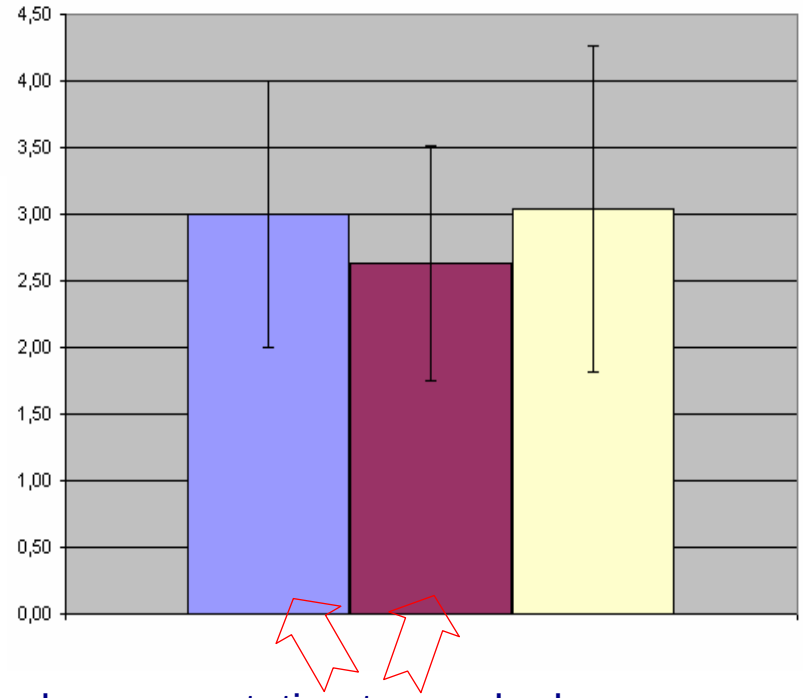
- Subjective measurements

Overall Workload Index (NASA TLX)



=> no additional overload

Overall driving quality



=> bar presentation top ranked

Summary

- *Pathway anticipation* enables reduction of car accidents
- There are solutions built for navy and aircraft
- AGP takes the driver back “in-the-loop” to avoid the time critical weakness of ACC Systems
- 3D HUDs using the *Breaking Bar* enables better understanding of own car’s movement
- First experiments on 3D HUDs yield promising results, but there are still many open directions to be researched

References

- www.worldcarfans.com, www.mobileye.com, www.webshots.com
- Continental Automotive System, Press Release, Nuremberg November 2004
- „ Integration of a Component Based Driving Simulator and Design of Experiments on Multimodal Driver Assistance “, Darya Popiv (2007)
- “Transfer of Flight-Tunnel-Presentations into the Head-Up Display of Cars”, Tönnis (2006)
- „Predictive Displays for Survey Vessels“, Sullivan et. al (2006)
- Statistisches Bundesamt. „Unfallgeschehen im Strassenverkehr 2002“, DeStatis, 2002

Thank you for attention.

Annex 1 – Partial List of ACC featured cars

- Acura RL, Audi A6, Audi A8, Audi Q7, BMW 3 Series (called Active Cruise Control), BMW 5 Series, BMW 7 Series, Cadillac DTS, Cadillac STS, Cadillac XLR, Honda Legend, Infiniti M, Infiniti Q45, Jaguar XK-R, Jaguar S-Type, Jaguar XJ, Lexus LS430/460, Lexus ES-350, Nissan Primera T-Spec Models (called Intelligent Cruise Control), Mercedes-Benz S-Class, E55 AMG, CLS, SL, CL, Range Rover Sport, Toyota Sienna XLE (limited availability), Toyota Avalon, Volkswagen Phaeton, Volkswagen Passat, Renault Vel Satis and Volvo S80 (Source: www.wikipedia.org)