Experimental Evaluation of an Augmented Reality Visualization for Directing a Car Driver's Attention.

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Experimental Evaluation of an Augmented Reality Visualization for Directing a Car Driver's Attention

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Overview

- Guidance of Car Driver‘s Attention
- Approach
- The Experiment
- Results

Guidance of Car Driver‘s Attention

- Increasing number of cars equipped with Head-up display (HUD) technology
- These help drivers to keep their eyes on the road
- Combined with sensing technology of modern cars, HUDs enable Augmented Reality visualizations for the driver

- As the driving task takes place in the windshield, AR mainly should assist the driver in driving

Guidance of Car Driver‘s Attention

- Control of Attention as a driving assistance to guide to dangerous situations
- Alerts often refer to a position which is currently out of sight for the car driver
- Augmentations cannot be placed at their true physical position
- Positioning within the driver's current field of view (i.e., windshield), telling him how to move his head to see the dangerous situation

Approach - A driver's task

- Global awareness
  - Navigational task - knowledge about the route to the destination

- Local guidance
  - Controlling the vehicle
  - Knowlegde about the environmental situation
  - Understanding the spatial relationship between a controlled object and is immediate surroundings

Approach – Related Work

- Egocentric visualizations for local guidance [1,2]
- Viewpoint tethering [3]: Local guidance improves by shortness of tether whereas global awareness performance deteriorates
- Visualization schemes:
  - Warning icons [4]: Orientational 2D arrows for upcoming obstacles
  - Compass metaphor [5,6]: 3D location pointer arrow best for surface navigation

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Approach – Visualization Schemes

- 2D presentation from an exocentric bird's eye perspective
- At fixed position in front of the windshield

Approach – Visualization Schemes

- 3D arrow floating in the driver's field of view
- Back end placed about 3 meters in front driver in height of a typical driver's head
- The front end points in the direction of the imminent danger

The Experiment - Setup

- Stationary driving simulator
- Simulated traffic scenes at focal distance of 3 meters in front of driver by 50 degree field of view
- HUD-based visualizations by a second appropriately calibrated projector on the same screen
- Car is surrounded by 16 evenly spaced, letter-sized sheets of paper and 4 more displayed on the projection screen, showing numbers 1 to 20

The Experiment - Procedure

- First phase for participant
  - Get familiar with the overall setup of the driving simulator
  - Drive down a rural road at usual speed following traffic rules and stay in the lane
- Second phase
  - Scenery augmented with visualizations of imminent danger
  - The participants were shown one of the visualization schemes
  - Procedure performed twenty times for each of the two schemes
- Third phase: Fill out subjective questionaire

The Experiment - Procedure

Second phase: Test on visualization schemes

- While driving, one of the schemes was shown
- The participants were expected to look as quickly as possible in the indicated direction and read out aloud the number of the paper sheet that they saw

The Experiment - Variables

- Independend Variable: *Visualization scheme*.
- Dependend Variables:
  - *Response time:* Time to reaction of driver
  - *Error quotient:* Percentage of wrong answers
  - (*Average mistake:* How many sheet positions off)
  - *Weighted average mistake:* Aggregated smaller angular differences in the car‘s rearside in case of the 3D arrow
  - *Average lane deviation:* Average distance of the car from the center of its lane

The Experiment - Analysis

- 12 Participants, ten males and two females between the ages of 22 and 49 (mean 27.8, standard deviation 13.9)
- Six started with bird‘s eye view visualization, six with the 3D arrow
- 20 dangerous situations per participant and visualization scheme (=> 480 records)
- T-Test for paired samples

Results – Response Time

Measured variable	Mean	Mean	Std deviation	Std deviation	Signifi-cance
	Bird	Arrow	Bird	Arrow	
Response time [s]	3.74	4.82	1.53	2.17	0.02

- The participants could directly get a feeling for the orientation of the alert by looking at the bird's eye view
- Monoscopic 2D projection of the 3D arrow is complicating the perception
- 3D arrow rendered on the projection plane in front of the car

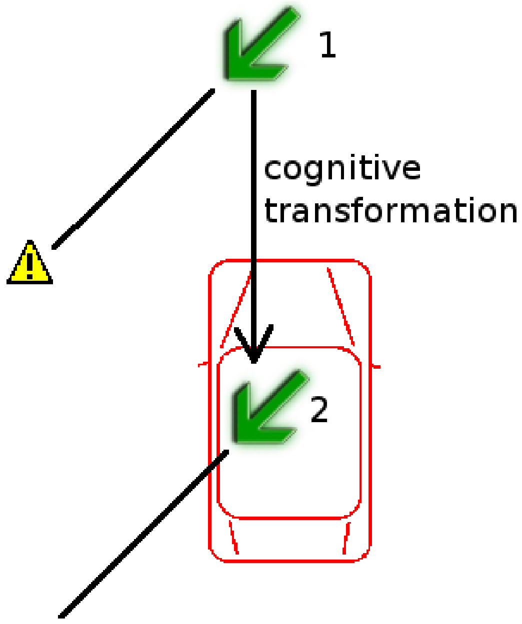
Results – Error Quotient, Weigh. Avg. Mistake

Measured variable	Mean	Mean	Std deviation	Std deviation	Signifi-cance
	Bird	Arrow	Bird	Arrow	
Error quotient	0.32	0.59	0.19	0.18	0.00
Weighted Average Mistake	0.33	0.88	0.21	0.63	0.006

- Arrow's direction is not as precisely interpreted on the HUD as the octagon in the bird's eye view
- Drivers mentally translated the arrow from the position in front of the car to their own eye position inside the car

Results - Mental Translation

- Position of the arrow in front of the car (1)
- Mental translation to driver‘s eye position inside car (2)



Results – Average Lane Deviation

Measured variable	Mean	Mean	Std deviation	Std deviation	Signifi-cance
	Bird	Arrow	Bird	Arrow	
Average lane devi-ation [m]	2.06	1.80	0.33	0.35	0.016

- Larger mental effort required in the bird’s eye presentation in order to transform from driver‘s own viewing frame into the bird’s frame and back to the car’s frame to find the correct sheet

Results – Subjective Answers

Measured variable	Mean	Mean	Std deviation	Std deviation	Signifi-cance
	Bird	Arrow	Bird	Arrow	
Preference	2	4	0.45	1.10	0.00
Ease of use	1.75	3.83	0.45	1.11	0.00
Speed	2	4	0.85	1.54	0.04
Precision	1.83	4	0.72	1.28	0.00

- Negative impression due to its current flat presentation on a projection screen, as discussed above.
- Inadequate display technology

Conclusion

- Egocentric visualization aides have proven superior to exocentric schemes for local guidance tasks in other scenarios
- We can not uphold this finding in our current user study

- Improve the simulator to determine what impact is generated by the inclusion of more realistic presentation technology
- Include a steroscopic HUD
- Explore different appearance patterns of the arrow to help drivers determine the correct orientation more easily
- Clearify the ambiguity stemming from the cognitive transformation that was noticed by some participants

Thank you for listening!

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Dangerous Situations Around the Car

- What can happen if a driver forget's to do exactly this glance?