

Survey and Classification of Head-Up Display Presentation Principles

Marcus Tönnis¹, Marina Plavšić², Gudrun Klinker¹

¹ Fachgebiet Augmented Reality
Technische Universität München

² Lehrstuhl für Ergonomie
Technische Universität München

Motivation

- Future HUDs might provide ways to superimpose the outside world with virtual information, i.e. enable Augmented Reality (AR)
- Various AR systems are already under development and run through user studies
- Problem: *Independent variables*
- Reason: AR visualizations use *multiple principles* of presentation. To clearly attribute measured effects to a specific independent variable only one principle may be changed between two variants
- Issue: Different system variants often have multiple parameters affected
- Awareness: Know about different principles of presentation before you start system and test design

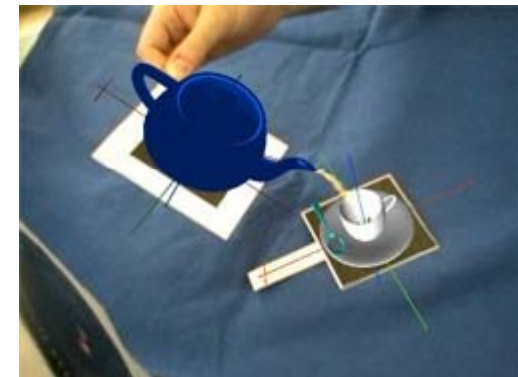
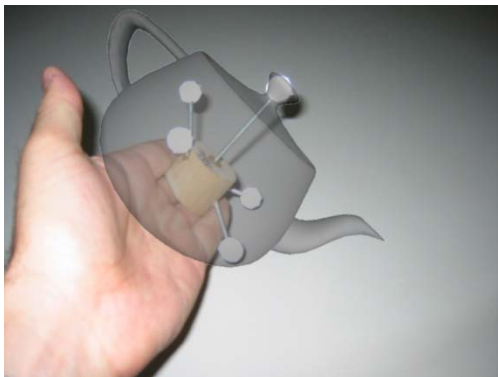
• Azuma, R. (1997). A Survey of Augmented Reality. Presence: Teleoperators and Virtual Environments, 6(4), 355–385

Overview

- 3D space for information presentation
- Classes of dimensions for information presentation
- Design examples and potential cross-relationships of designs
- Conclusion

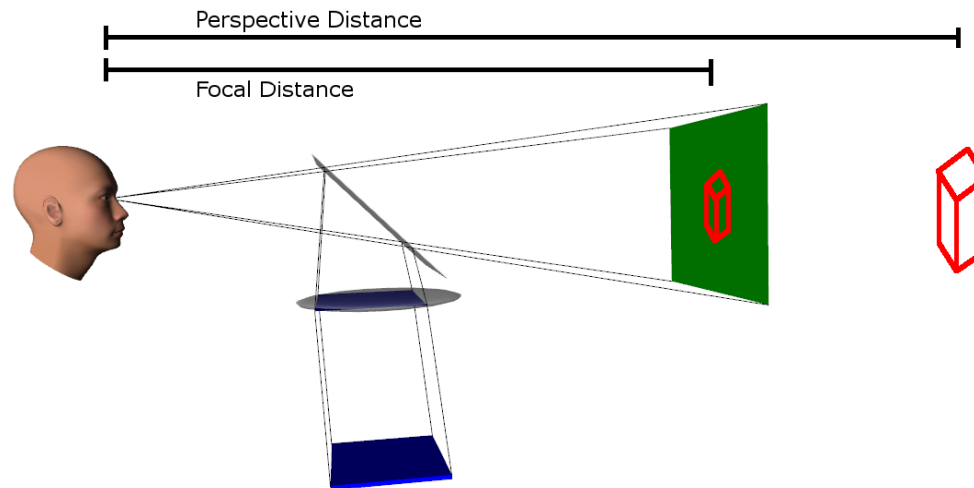
3D Space for Information Presentation

- With AR, information no longer requires stationary displays as carrier - it can move into the surrounding world
- With the paradigm of AR, information has the potential to be presented at the direct place where the origin for the need of information presentation is located
- Instead of 2D on conventional displays, AR extends to 3D



Issues of the 3D Presentation Space

- Information **locally fixed** to the environment **moves** over the HUD
- Dynamic layouting for avoidance of occlusion of relevant objects
- Focal accommodation – depth queues



Classes of Dimensions for Information Presentation I

- Continuous vs. Discrete Information Presentation
 - Continuous information must not be immersive information
 - Discrete information (e.g. warning events) cause driver to leave control circuit of driving task
- 2D Symbolic vs. 3D Information Presentation
 - 2D symbolic information can use flat icons
 - 3D information renders virtual 3D objects
- Contact-analog vs. Unregistered Presentation
 - Information may be registered with the environment (contact-analog)
 - Information may be placed independently of a location in the surrounding

Classes of Dimensions for Information Presentation II

- **Presentation in Different Frames of Reference**
 - Virtual information can be presented from the driver's point of view, embedding in the perceived scenery
 - Virtual information can also use another frame of reference – e.g. a bird's eye map
- **Direct vs. Indirect Referencing of Objects or Situations**
 - Direct referencing refers to objects that reside in the drivers field of view
 - Indirect referencing refers to objects that lie occluded in the drivers field of view
 - Pure referencing intends to guide the attention of the driver to a direction outside the field of view
- **Location of Presentation in Relation to Glance Direction**
 - With glance tracking systems, information can be placed w.r.t. the glance direction of the driver
 - Issues are not to obstruct the view but to keep the information perceivable

Design Examples and potential Cross-relationships of Designs

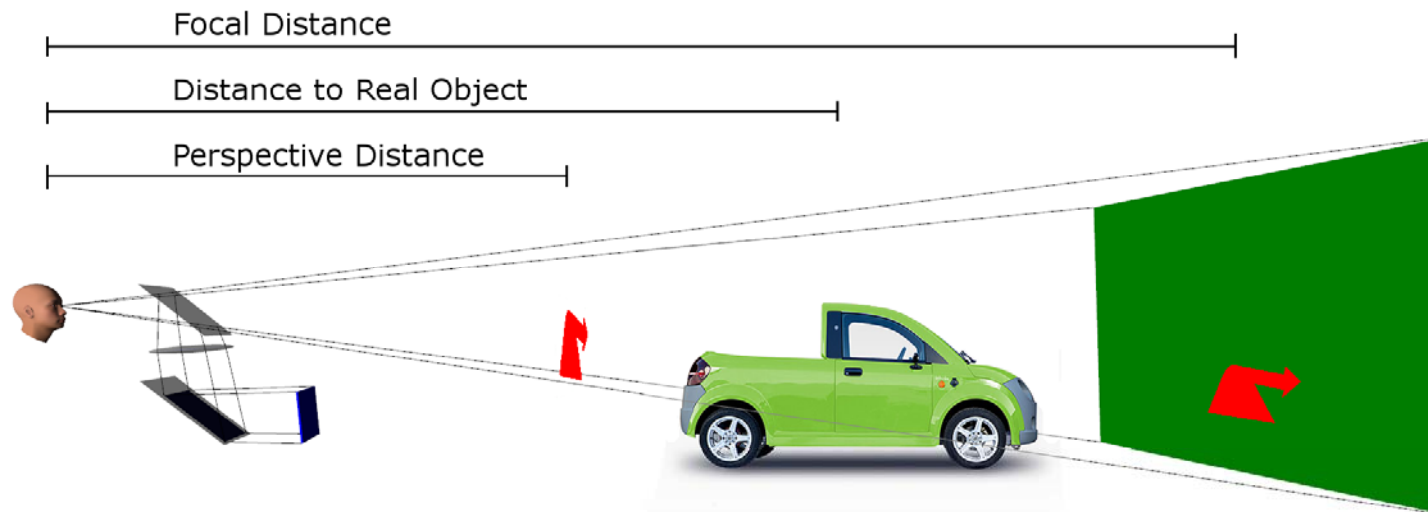
- Paper illustrates and discusses pair-wise combinations of dimensions

Continuity (1)	-					
Representation (2)	X	-				
Registration in Space (3)	X	X	X			
Frame of Reference (4)	X	X	X	-		
Type of Reference (5)	X	X	X	X	-	
Glance Relation (6)	X	X	X	X	X	-
	1	2	3	4	5	6

- Only marked will be illustrated in subsequence – see paper for full survey

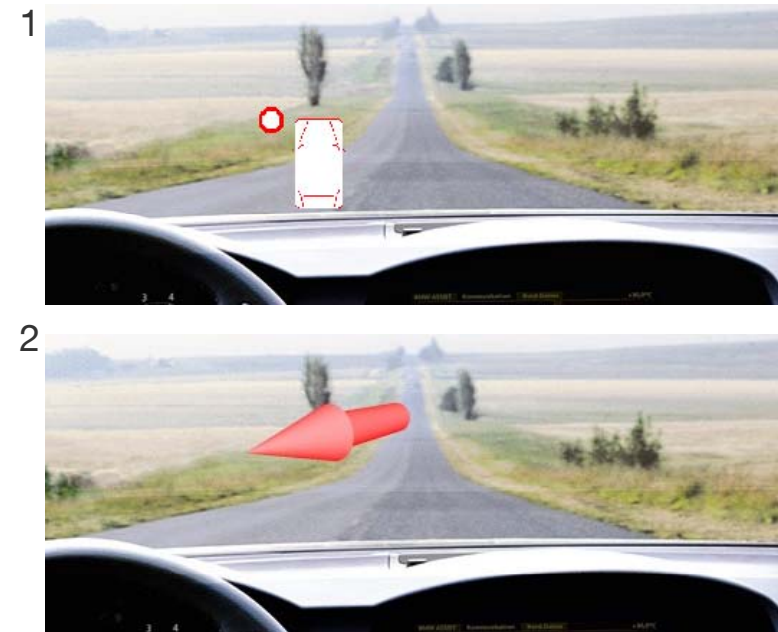
Constraints of Display Technology (3)

- Human eye focuses to the **focal distance** to perceive the image
- Image is rendered in a **perspective distance** shorter than a **real object** (green car).
- => Reverted Depth Cue



Registration in Space vs. Type of Referencing (3 vs 5)

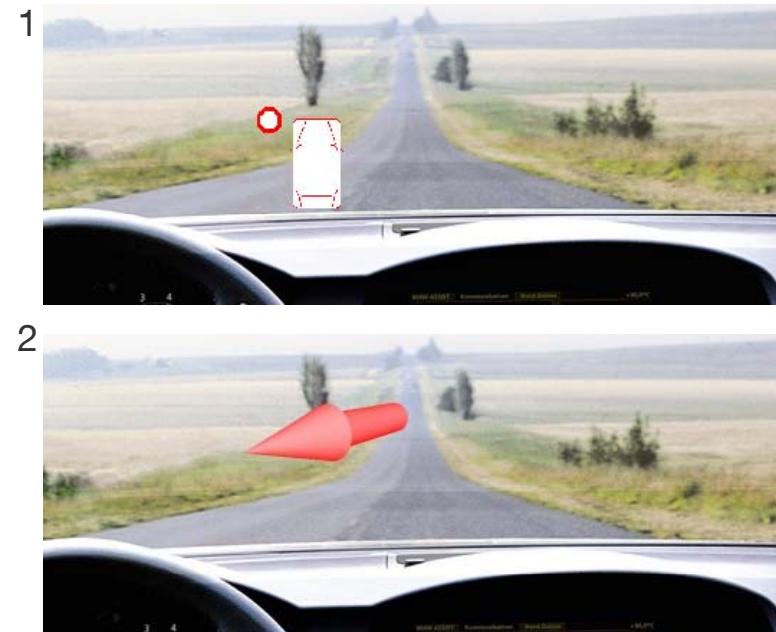
- Example: system for guidance of a car driver's attention
- Different registration in space
 - Bird's eye scheme is unregistered (1)
 - 3D arrow is contact-analog (2)
- Different types of referencing
 - Bird's eye scheme shows location (1)
 - 3D arrow shows direction (2)
- Issues when testing
 - Benefit for pointing to location instead of pointing to a direction? (1)
 - Benefit for information embedded into the world (less need for transformation between frames of reference)? (2)



- Tönnis, M., Sandor, C., Lange, C., Klinker, G., & Bubb, H. (2005, October). Experimental Evaluation of an Augmented Reality Visualization for Directing a Car driver's Attention. In Proceedings of the International Symposium on Mixed and Augmented Reality (ISMAR)
- Tönnis, M., & Klinker, G. (2006, October). Effective Control of a Car Drivers Attention for Visual and Acoustic Guidance towards the Direction of Imminent Dangers. In Proc. of International Symposium on Mixed and Augmented Reality (ISMAR)

Registration vs. Frames of Reference (3 vs 4)

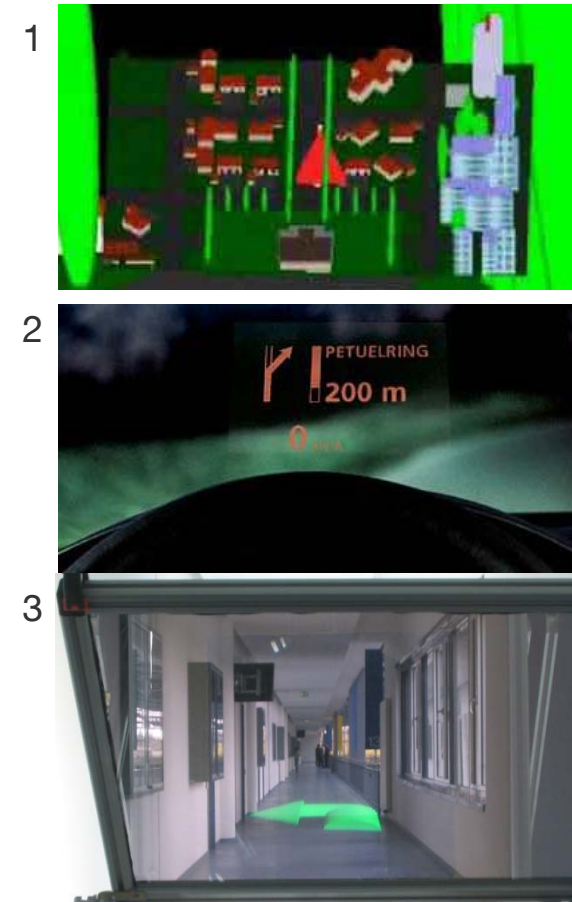
- Example: system for guidance of a car driver's attention
- Different registration in space
 - Bird's eye scheme is unregistered (1)
 - 3D arrow is contact-analog (2)
- Different frames of reference
 - Bird's eye: Transform to coordinate system presentation - gather information - transform back to real world coordinate system – interpret (1)
 - 3D arrow: Embedded as object floating in the world coordinate system (2)



- Tönnis, M., Sandor, C., Lange, C., Klinker, G., & Bubb, H. (2005, October). Experimental Evaluation of an Augmented Reality Visualization for Directing a Car driver's Attention. In Proceedings of the International Symposium on Mixed and Augmented Reality (ISMAR)
- Tönnis, M., & Klinker, G. (2006, October). Effective Control of a Car Drivers Attention for Visual and Acoustic Guidance towards the Direction of Imminent Dangers. In Proc. of International Symposium on Mixed and Augmented Reality (ISMAR)

Representation vs. Frame of Reference (2 vs 4)

- Example: Navigation systems
- Different frames of reference
 - North Up: Exocentric (1)
 - Face Up: Exocentric, but motion compensated to egomotion (2)
 - AR presentation: Fully egocentric (in perspective and in motion behavior) (3)
- Varying Representation
 - 2D: Available HUD (2)
 - 3D: In embedded visualization (1) and AR (3)
- To which variation do results of studies attribute to?



- Colquhoun, H., & Milgram, P. (2000). Dynamic Tethering for Enhanced Remote Control and Navigation. In Proceedings of the International Ergonomics Association (IEA), Human Factors Ergonomic Society (HFES) (pp. 146–149)
- Lamb, M., & Hollands, J. G. (2005). Viewpoint Tethering in Complex Terrain Navigation and Awareness. In 49th Annual Meeting of the Human Factors and Ergonomics Society

Registration vs. Glance Behavior (3 vs 6)

- Virtual objects can/could be registered to the glance behavior of the user
- Upcoming issues
 - Direct registration to the line of sight (foveal area of retina) occludes the whole surrounding
 - Adding a static offset to the virtual object disables looking at the virtual object – it always keeps its offset to the line of sight
- Floating algorithms are necessary to establish a relation between an object of concern, its associated information and the dynamic placement of this information

Conclusion

- Spatial AR displays are not yet explored and standardized as conventional 2D displays are
- System development must carefully focus on even small changes to a presentation strategy
- Even minor changes may change the test outcome of a system in comparison to another
- Knowing about presentation principles and possible cross-relationships can avoid misleading results of user studies
- Future work has to investigate these dimensions to reveal foundations for presentation concepts

In other words...

- Next time you develop two systems and put them into a user study, e.g., a
 - **Continuous, 3D** presentation with **contact-analog registration** in space showing **egocentric** information and referring **directly** to the object of concern and in **not glance mounted**
 - **Discrete, 2D** presentation **without spatial registration** showing its information in an **exocentric** manner but **indirectly** refers to the object of concern thereby being **glance mounted**
- Think if you really want to treat all these principles as one independent variable!

Survey and Classification of Head-Up Display Presentation Principles

Marcus Tönnis¹, Marina Plavšić², Gudrun Klinker¹
Contact: toennis@in.tum.de

¹ Fachgebiet Augmented Reality
Technische Universität München

² Lehrstuhl für Ergonomie
Technische Universität München
