

Proseminar Medieninformatik

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Research Questions

The human being in Virtual Reality

The way of interacting with head mounted display (HMD) based fully immersive virtual environments is in focus of science for decades. Nevertheless the relevance to work scientifically on this topic got a big push by the development of high quality but cheap consumer products. These products not only change the price, but also they change the whole user experience. Because of that a growing population of untrained people, not able or interested to use these technologies till now, will be the new user population in private and professional use. For the UX specialists this development gives a lot of questions to answer.

Virtual reality systems are complex from a technological, psychological and philosophical point of view. Therefore I want to address these different topics in our work. Our group research shall start with a scientific overview about virtual reality systems, followed by a view on what happens in the users mind when interacting in such a system. The further development of VR Systems will be driven by interaction in the VR and furthermore by people acting in different environments.

For the research you will find a very brief abstract about your research question. The keywords and reference work is just a help for the start. Feel free to change them to the experience you make while searching for literature.

At first we want to know more about VR Reality. The most basic question is:

1st research question: What is a HMD based virtual reality system? Obviously it needs hardware, like the HMD and the computer. But what is the definition of a VR System? What are the most important manifestations of the single subsystems according to this definition? Based on the research, please discuss, what would be the most promising combination of subsystems for a multi-user interaction game.

Keywords: *virtual reality systems, head mounted display, immersive environments*

Reference Work: Blade, R. & Padgett, M.L. (2014). Virtual Environments Standards and Terminology. In K. Hale & K. Stanney, *Handbook of Virtual Environments: Design, Implementation, and Applications* (pp. 21-33).

Even so today we can gather and stimulate all human senses, there will always be a certain difference to the real world. Virtual environments have a well know issue about distorting the visually perceived size and/ or distance to an object. Further they cause physical stress to the human being. But all this seems to be related to personal factors. The following questions shall help to get a quick insight on this topics.

2nd research question: What are the main reasons for the shift in the perception of size and egocentric distance to objects when using a Head Mounted Display in? What are the methods to deal with those problems?

Keywords: *perception, virtual environments, egocentric distance*

Reference Work: Renner, R. S., Velichkovsky, B. B. & Helmert, J. R. (2013). The perception of egocentric distances in Virtual Environments - a Review. *ACM Computing Surveys*, 46 (2).

3rd research question: Calibration of Head Mounted Display can help to get rid of different optical issues. What kind of calibration methods are known in the literature and what are their tradeoffs? Which one should be preferred or should they be combined?

Keywords: *head mounted displays, calibration, virtual reality*

Reference work: Kuhl S., Thompson W. & Creem-Regehr S. (2008). HMD calibration and its effects on distance judgments. *Proceedings of the 5th symposium on Applied perception in graphics and visualization (APGV '08)*. ACM, New York, NY, USA, 15-22. doi: 10.1145/1394281.1394284

4rd research question: Determine the influence of interpupillar distance on the interaction of the user with the virtual environment? Does it change navigation performance or the interaction with objects compared to reality?

Keywords: *head mounted displays, virtual reality, navigation performance, object manipulation*

Reference work: Sherstyuk A. & State A. (2010). Dynamic eye convergence for head-mounted displays. In *Proceedings of the 17th ACM Symposium on Virtual Reality Software and Technology (VRST '10)*, 17, 43-46.

5th research question: What is “cybersickness” and its’ cause in terms of a fully immersive virtual environment? What are the methods to evaluate “cybersickness”? Discuss their differences and give some advice to prevent cybersickness.

Keywords: *cybersickness, head mounted display, virtual reality*

Reference work: Young, S., Adelstein, B., Ellis, S. (2006). Demand Characteristics of a Questionnaire Used to Assess Motion Sickness in a Virtual Environment. In *Virtual Reality Conference*, 97-102.

6th research question: VR technologies have an inhibition level that depends on the users personal factors. What are the main factors that generate the inhibition level and what is the influence of age, gender or profession on the will to use virtual environments?

Keywords: *role model, gender, sex, age, virtual reality, head mounted display*

Reference work: Felnhofer, A., Kothgassner, O.D., Beutl, L., Hlavacs, H. Kryspin-Exner, I. (2012). Is Virtual Reality made for Men only? Exploring Gender Differences in the Sense of Presence. In *Proceedings of the International Society on Presence Research*.

The technique has a physical influence on the user, so he might change his natural behavior: To understand this influence we need to get some first insight in this by the following questions.

7th research question: What is the influence of the physical presence of a HMD on the user while walking around and exploring an environment?

Keywords: *immersive environment, head mounted display, navigation, distance, spatial awareness*

Reference work: Kevin W.A. (2000). *Effects of Field of View on Performance with Head-Mounted Displays*. (Ph.D. Thesis), The University of North Carolina, Chapel Hill.

8th research question: To give the user the possibility to interact with the virtual world, he will need a representation of its body. What is the influence of the virtual representation of the human body and what changes in the users experience, if this representation doesn't look like the real body part?

Keywords: *virtual hands, head mounted display, embodiment, rubber hand illusion, taxonomy*

Reference Work: Perez-Marcos, D., Sanchez-Vives, M. V. & Slater, M. (2012). Is my hand connected to my body? The impact of body continuity and arm alignment on the virtual hand illusion. In *Cognitive Neurodynamics*, 6(4), 295–305.

When putting people into a HMD based virtual reality system, their psychological relation to the virtual environment changes. To describe this change the measurement of the feeling to be present in the VR can be used:

9th research question: What is “presence” in terms of a fully immersive virtual environment and what are scientific methods to evaluate presence? Discuss the differences of the methods and choose the most scientific one to be used for the analyse of the virtual reality system in further studies.

Keywords: *presence, immersive environment, head mounted display,*

Reference Work: Slater M. (1999). Measuring Presence: A Response to the Witmer and Singer Presence Questionnaire. In *Presence: Teleoperators and Virtual Environments*, 8(5), 560-565.

While working with a fully immersive virtual environment you can observe very soon, that the user wants to interact with his surroundings. And even faster you will discover how complex a simple grasping task can be for the VR user:

10th research question: There is no physical object to grab in the virtual world, therefore the computer has to analyze, if it was the users intention to grasp/ select an object or not. How can these methods be classified and what would be the best choice to use in an interactive VR environment in terms of presence, effectiveness and efficiency?

Keywords: *3D interaction; 3D selection; Virtual pointing; Virtual reality*

Reference Work: Argelaguet F., Andujar C. (2013). A survey of 3D object selection techniques for virtual environments. In *Computers & Graphics*, 37(3), 121-136.

11th research question: The precision of the representation and replication of the real hand in the virtual world depends on a lot of factors. What are the effects of an inaccurate representation of the real hand in the virtual world?

Keywords: *virtual hand, avatar, interaction, immersive environments, virtual reality, head mounted display*

Reference Work: Kiltani K., Normand J-M., Sanchez-Vives MV., Slater M. (2012). Extending Body Space in Immersive Virtual Reality: A Very Long Arm Illusion. *PLoS ONE*, 7(7). doi:10.1371/journal.pone.0040867

12th research question: In terms of creating a natural user interface, finger tracking integrates the users fingers in the virtual environment for direct manipulation of objects. How is finger tracking realized and what are the challenges researches aim on, to create a better experience?

Keywords: *finger tracking, motion tracking, virtual reality, hand tracking*

Reference Work: Chapoulie, E., Marchal, M., Dimara E., Roussou M., Lombardo, J.C., & Drettakis, G. (2014). Evaluation of direct manipulation using finger tracking for complex tasks in an immersive cube. In *Virtual Reality*, 18(3), 203-217. doi: 10.1007/s10055-014-0246-0

13th research question: Many users report a lag of trust in manipulating virtual objects without a real representation. That is why we need to answer the question, if the users performance in interacting with virtual object is higher, if haptic feedback is offered.

Keywords: force feedback, haptic interfaces, haptics, collision detection, virtual reality, object manipulation

Reference Work: Wildenbeest, J., Abbink, D., Heemskerk, C., van der Helm, F., Boessenkool, H. (2013). The Impact of Haptic Feedback Quality on the Performance of Teleoperated Assembly Tasks. In *Haptics, IEEE Transactions on*, 6(2), 242-252. doi: 10.1109/TOH.2012.19

14th research question: What is Gaze-/ Eye-Tracking useful for in virtual environments. Focus on interacting with virtual UIs and navigating in virtual environments?

Keywords: Gaze-Tracking, Eye-Tracking, virtual reality, head mounted displays, user interfaces, navigation

Reference Work: Stengel, M., Grogorick, S., Eisemann, M., Eisemann, E. & Magnor, M. (2015). An Affordable Solution for Binocular Eye Tracking and Calibration in Head-mounted Displays. In *Proceedings ACM Multimedia*.

15th research question: One idea to use Eye-Tracking in head mounted displays is to reduce the calculation load for the computer. What are the techniques to reduce the load, based on the spot the viewer glances at and what are the perceptual reasons that this idea works?

Keywords: Gaze-Tracking, Eye-Tracking, virtual reality, head mounted displays, rendering, perception.

Reference Work: Peli, E (1999). Optometric and perceptual issues with head-mounted displays. In Mouroulis, P. (ed.), *Visual Instrumentation: Optical Design And Engineering Principles* (pp. 205-276). McGraw-Hill, New York, USA.

16th research question: What are “gaze gestures” in general and what are their drawbacks? What would be the most promising use cases for interaction design in head mounted displays?

Keywords: Gaze-Tracking, Eye-Tracking, virtual reality, head mounted displays, gaze gestures

Reference Work: Drewes H. & Schmidt, A. (2007). Interacting with the computer using gaze gestures. *Proceedings of the 11th IFIP TC 13 international conference on Human-computer interaction - Volume Part II (INTERACT'07)*, 475-488.

17th research question: For the interaction with the virtual world, the design of the UI often leads to the term natural user interface (NUI). What is the definition of a NUI? What are the most promising NUI concepts and which would you choose for a multi-user environment?

Keywords: Gaze-Tracking, Eye-Tracking, virtual reality, head mounted displays, object selection, object manipulation, pointing task, selection task

Reference Work: Emma-Ogbangwo, C. Cope, N., Behringer R., & Fabri M.(2014). Enhancing User Immersion and Virtual Presence in Interactive Multiuser Virtual Environments through the Development and Integration of a Gesture-Centric Natural User Interface Developed from Existing Virtual Reality Technologies. *HCI International 2014 - Posters' Extended Abstracts*, 410-414. doi: 10.1007/978-3-319-07857-1_72

18th research question: Interaction also means walking around in VR. But to walk around in VR needs either some kind of treadmill or a lot of space to walk around. In our lab we don't have a treadmill and not much space. But there's the idea of redirected walking. How does it work? Is redirected walking a solution to scale down the necessary room space for exploring big virtual environments while walking in a real room? Compare some studies.

Keywords: redirected walking, Perception; Virtual reality; Immersive virtual environment

Reference Work: Bruder G., Steinicke F., Bolte B., Wieland P., Frenz H., & Lappe M. (2013). Exploiting perceptual limitations and illusions to support walking through virtual environments in confined physical spaces. *Displays*, 34(2), 132-141.

19th research question: In the end there might be no chance, that it is possible to get everything rendered for the human senses, as it is in the real world. But is it possible to estimate how good we have to be, to give enough and qualitative stimuli to the senses? Discuss the given theories from the human factors side.

Keywords: Gaze-Tracking, Eye-Tracking, virtual reality, head mounted displays, object selection, object manipulation, pointing task, selection task

Reference Work: Simpson B.D., Cowgill J.L., Gilkey R.H., & Weisenberger J.M.(2014). *Technological Considerations in the Design of Multisensory Virtual Environments: How Real Does it Need to Be?* In Hale, K.S., & Stanney K.M., *Handbook of Virtual Environments: Design, Implementation, and Applications, Second Edition* (pp. 313-334).

After gaining knowledge about the single user in the VR System, we need to gather some more knowledge about the multi-user System. The focus with Multi-User applications is on the drawbacks introduced by VR technology.

20th research question: To describe the relation between a VR user and his interlocutor the concept of social presence is used. What is social presence? How can it be quantified and what are the main factors to generate high social presence between people communicating in a HMD environment.

Keywords: *collaborative virtual environments, collaboration, modalities, media richness, social presence, presence*

Reference Work: Sallnäs, E. (2004). The effect of modality on social presence, presence and performance in collaborative virtual environments. In *PRESENCE*, 14(4), 434-449. doi:10.1162/105474605774785253