HYBRID SOCIETIES

TECHNISCHE UNIVERSITÄT CHEMNITZ

EXPERT WORKSHOP: SPATIAL ORIENTATION IN VIRTUAL ENVIRONMENTS

June 30th to July 1st, 2021

PROGRAM

Funded by
DFG Deutsche Forschungsgemeinschaft
German Research Foundation

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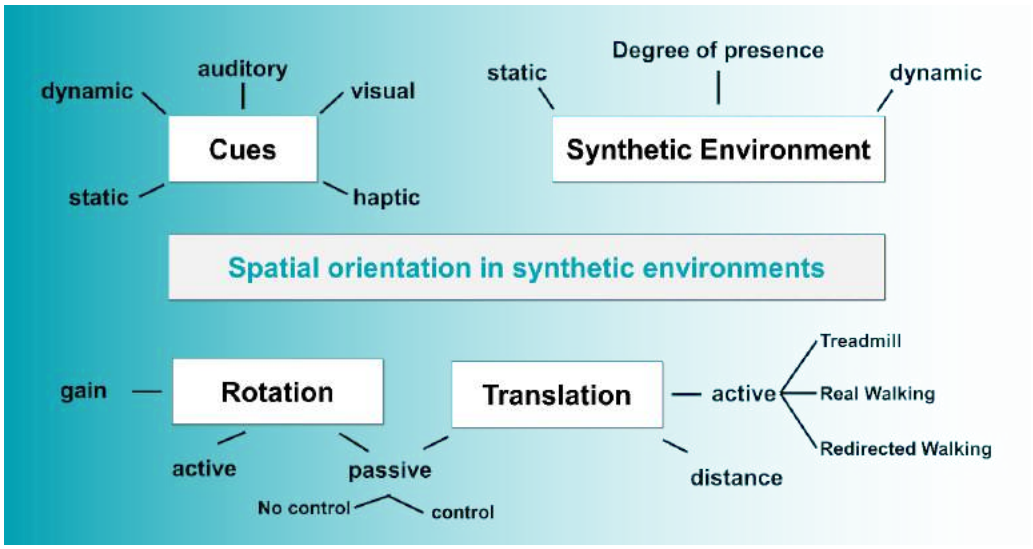
Collaborative Research Centre Hybrid Societies

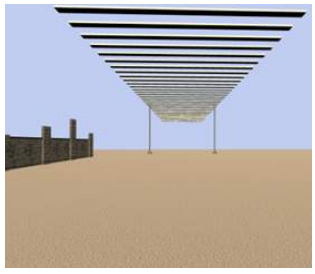
Research in the CRC Hybrid Societies aims at what is required so that humans can coordinate with Embodied Digital Technologies (EDTs) as smoothly as with conspecifics and how EDTs must be designed to meet these requirements. It pertains to the interaction of humans with (EDTs) as artificial bodies moving in real or virtual environments, but also to wearable EDTs extending and enhancing the human body as well as to those that provide evolutionary novel experiences to the human mind.

https://hybrid-societies.org

WORKSHOP GOALS

Supportive sensory experiences can be used to improve spatial orientation in virtual scenarios. For this purpose, on the one hand, cues can be made available via sensory channels (visual, auditory, haptic) or the possible real self-movements (translation, rotation) providing proprioceptive and vestibular cues as well as motor efference and can be changed. The abundance of possibilities, both with regard to cues as well as research methods to be used, should be discussed. The workshop is intended to exchange ideas about methodological challenges, open research questions, and possible collaborations.





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CONTRIBUTIONS

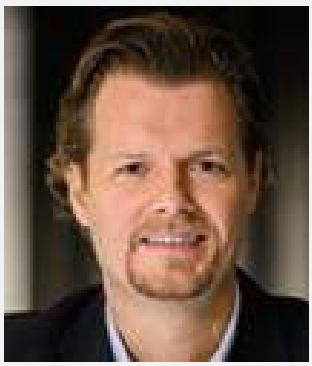
HYBRID SOCIETIES: HUMANS INTERACTING WITH EMBODIED TECHNOLOGIES – BRIEFLY PLACING THE WORKSHOP IN CONTEXT

Prof. Dr. Georg Jahn - Applied Geropsychology and Cognition, Faculty of Behavioural and Social Sciences, Chemnitz University of Technology

This workshop is organized as part of the research and networking activities within the CRC 1410 Hybrid Societies that has been established 2020 with funding by the German Research Foundation (DFG). The CRC gathers researchers from psychology and engineering to mathematics and computer science to the social sciences and humanities. In the CRC, we study how humans can efficiently and safely coordinate, for example, with autonomous vehicles and robots that they encounter in public spaces. Virtual reality is employed to simulate such encounters but closer to the workshop topic are research activities on spatial orientation and spatial presence in virtual and synthetic environments. Autonomously acting embodied technologies can temporarily or partly be monitored, directed, or operated remotely by humans. Such scenarios involve challenges of spatial orientation because of, for example, limited sensory feedback for spatial updating during self-motion in synthetic environments or sudden relocation. The demand for sudden spatial orientation can also occur for the real world at take-over requests by highly automated vehicles. In addition to processes of spatial orientation, spatial presence, and spatial updating, we are interested in how virtual or augmented reality can provide support for this and similar challenges of spatial orientation.

BENDING SPATIAL PERCEPTION; COGNITION AND ACTION IN VIRTUALITIES

Prof. Dr. Frank Steinicke - Chair of Human-Computer Interaction; Department of Informatics, Universität Hamburg



The human perception-action loop is full of imperceptions, which optimize the way how humans perceive, understand and interact with their environment. In my talk, I will show some examples how this imperception can be exploited in order to improve the user experience and performance in computer-mediated realities.

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SPATIAL ORIENTATION AND SPATIAL REFERENCE SYSTEMS

Prof. Dr. Timothy P. McNamara - Professor of Psychology, Cognition and Cognitive Neuroscience, Vanderbilt University

Human spatial navigation is a complex cognitive activity that depends on perception, action, memory, reasoning, and decision-making. To navigate effectively, humans must maintain their orientation in the environment during movement. The perceptual and cognitive processes that support spatial orientation make use of many spatial cues, including landmarks, environmental geometry, remembered spatial relations, and body-based cues to self-motion (e.g., proprioception). I will review our research on spatial orientation in virtual environments, with a particular focus on the spatial reference systems used in perception and memory to organize the spaces of navigation.

MOBILE BRAIN/BODY IMAGING (MoBI) OF NATURAL SPATIAL COGNITION

Prof. Dr. Klaus Gramann - Biological Psychology and Neuroergonomics, Berlin Institute of Technology, Director Department of Psychology and Ergonomics

Recent years have shown a remarkable shift in using established EEG technologies outside traditional lab environments recording brain dynamics in actively behaving participants in complex technical setups or the real world. This shift in EEG research comes with new challenges regarding recording hardware and analyses approaches sometimes leading to difficulties in comparing the results with established laboratory EEG-parameters associated with cognitive processes. I will provide a short overview of the background of Mobile Brain/Body Imaging (MoBI) and will present results from MoBI-experiments investigating multisensory integration during spatial orientation and new approaches to investigating the neural basis of spatial cognition using VR technology. The presentation will discuss new insights gained from MoBI studies and issues of replicability of established neural parameters. Potential new insights from experiments investigating natural cognition including the use of the human physical structure in different task scenarios will be highlighted.

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HOW REAL IS VIRTUAL REALITY

Prof. Dr. Andreas Kunz - Head of Innovation Center Virtual Reality, Department of Machine Tools and Manufacturing, ETH Zurich

Virtual environments become increasingly realistic and sophisticated interfaces allow for an intuitive interaction. Navigating virtual environments by real walking is possible, even if they are larger than the available physical space. However, is this degree of realism already sufficient to trigger the same unconscious effect as the real world would do? Do users behave different in VR than in reality? Here, spatial perception plays an important role that could enable VR to be used in various application fields such as training, assessment, workplace optimization, layout planning, and others.

(MIS-) PERCEPTION OF SPATIAL ASPECTS IN VIRTUAL REALITY

Prof. Dr. Eike Langbehn - Professor for Media Informatics, Department of Media Technology, Faculty of Design, Media and Information, Hamburg University of Applied Sciences

Perception in virtual environments is different than in the real world in many aspects. Distances and sizes are underestimated in the most cases, virtual and real speed are not perceived in the same way, and the dominant scale can be estimated individuallydifferent. Because an acurate perception is important for many interaction tasks, e.g. walking, grabbing, or navigation, we are examining ways to overcome these misperceptions. On the other side, limitations of the human perceptual system may also be usedto create spatial illusions that can be exploited to implement advanced interaction techniques.

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SPATIAL ORIENTATION IN SYNTHETIC ENVIRONMENTS

Dr.-Ing. Philipp Klimant - Professorship Production Systems and Processes, Faculty of Mechanical Engineering, Chemnitz University of Technology;
Division Director Process Digitalization and Manufacturing Automation, Fraunhofer Institute Machine Tools and Forming Technology IWU

The continuous spatial updating during self-motion is a process that contributes significantly to spatial orientation in the real world. In virtual or synthetic environments, however, this process is often disrupted or incompletely supported. In order to improve spatial orientation in virtual scenarios, the user needs sensory experience that can trigger update mechanisms. The main question addressed in subproject C02 of the Collaborative Research Centre Hybrid Societies is how best to induce the necessary sensory experiences for supporting continuous spatial updating to preserve spatial orientation in synthetic environments. To this end various experiments and techniques will be used, to study the process of continuous spatial updating, enabling conditions and factors influencing continuous spatial updating.

SPATIAL COGNITON PERFORMANCE IN PRIMARY SCHOOL CHILDREN

Prof. Dr. Gabriele Janzen and Claudia van Dun - Behavioural Science Institute and Donders Institute for Cognitive Neuroimaging, Radboud University Nijmegen

To successfully navigate it is necessary to store crucial locations in memory. We present two studies that have investigated this ability in primary school children aged 8-11. One fMRI study investigated the neural correlates as a result of a 5 day training in a virtual environment. Before and after training children completed a virtual object learning task in the MRI scanner. When global landmarks were used to guide navigation, activity in the hippocampus decreased with training, and when local landmarks were used, activity in the caudate nucleus decreased with training whereas activity in the hippocampus increased. A further behavioural study investigated sex differences and the role of gaming experience in a similar but more naturalistic virtual reality object location task. Overall, girls and boys performed equally accurate, although there was an increase in accuracy with age for boys. Boys navigated faster than girls, and this difference increased with age. More gaming experience in boys versus girls did not explain any result observed. Our results indicate that primary school children flexibly start using the geometric configuration of landmarks to guide navigation. Second, we demonstrate that sex differences in spatial skills, favouring boys are already present in primary school children.

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THE INTEGRATION OF ARTIFACTUAL CUES WITH LANDMARK AND BODY-BASED CUES

Phillip Newman - Cognition and Cognitive Neuroscience, Department of Psychology, Vanderbilt University

Mobile organisms use spatial cues to navigate effectively in the world. Recent work has demonstrated that human navigators can optimally combine landmark and body-based cues during homing. However, new technologies (e.g., virtual and augmented reality) provide additional cues to navigation, such as digital over-head maps (artifactual cues), which are increasingly relevant with the advent of Global Positioning Systems and assisted navigation. In the current study, human navigators performed a homing task in immersive virtual reality. Navigators first walked a two-legged outbound path before attempting to return to the beginning of the path (home path). The number of cues available during the home path was systematically manipulated. In single-cue trials, navigators had access to all three cues. In conflict trials, all three cues were available, but were placed in conflict. Statistically optimal cue combination was predicted from response variability in the single-cue conditions. Navigators were more precise during homing when they had access to all three cues. However, performance in conflict trials suggests that artifactual cues were integrated with landmark or body-based cues depending on which cues were placed in conflict.

ICY ROAD AHEAD – GAZE DURING PERTURBED WALKING

Dr.rer.nat. Karl Kopiske - Postdoctoral Researcher, Cognitive Systems Lab, Institute of Physics, Chemnitz University of Technology

Most humans can walk effortlessly across uniform terrain even without paying much attention to it. However, most natural terrain is far from uniform, and we need visual information to maintain stable gait. In a controlled yet naturalistic virtual environment, we simulated terrain difficulty through slip-like perturbations that were either unpredictable (experiment 1) or sometimes followed visual cues (experiment 2) while recording eye and body movements using mobile eye tracking and full-body motion tracking. We quantified the distinct roles of eye and head movements for adjusting gaze on different time scales. While motor perturbations mainly influenced head movements, eye movements were primarily affected by visual cues, both immediately following slips, and –to a lesser extent –over 5-minute blocks. We find adapted gaze parameters already after the first perturbation in each block, with little transfer between blocks. In conclusion, gaze-gait interactions in experimentally perturbed naturalistic walking are adaptive, flexible, and effector-specific.

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SPATIAL UPDATING OF TARGET LOCATIONS IN VIRTUAL REALITY

Zhanna Borodaeva - Professorship of Applied Geropsychology and Cognition, Institute of Psychology, Faculty of Behavioural and Social Sciences, Chemnitz University of Technology

Spatial updating in virtual environments is usually impaired by a lack of cues to self-motion. We report an experiment studying two types of support for spatial updating to preserve spatial orientation in synthetic environments. We varied the availability of a wall close to a target as a landmark for reproducing the target's location and we varied the availability of additional visual stimulation during self-motion intended for strengthening the impression of optic flow. Participants wore a head-mounted display standing upright and performed a pointing task after passive forward translation in a virtual scene. Before translation, two target objects were presented, some of them close to a lateral wall. They disappeared and the location of one of the target objects had to be indicated by pointing after translation. In a subset of trials, a stripe pattern above the translation path was presented during translation to increase the impression of optic flow. Pointing error on the forward axis was reduced by the lateral wall as spatial reference for close target locations, the stripe pattern did not improve performance. In future experiments, real self-motion and further navigation techniques, different multimodal cues, different tasks, and different kinds of virtual environments will be studied.

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PROGRAM

30th June 2021

2:45pm	*Login*
3:00pm	Welcome and Introduction *Prof. Dr. Georg Jahn*
3:15pm	Talks of participants and virtual lab tours *Prof. Dr. Frank Steinicke, Prof. Dr. Timothy McNamara, Prof. Dr. Klaus Gramann, Prof. Dr. Andreas Kunz, Prof. Dr. Eike Langbehn*
5:00pm	*Coffee break /informal virtual meetings*
5:15pm	Discussion of research gaps and methodological challenges
7:00pm	*Informal virtual meetings*

1st July 2021

2:30pm	*Login + Wrap up* *Prof. Dr. Georg Jahn, Dr.-Ing. Philipp Klimant, Jennifer Brade*
3:00pm	Talks of participants and virtual lab tours *Dr.-Ing. Philipp Klimant, Prof. Dr. Gabriele Janzen & Claudia van Dun, Philipp Newman, Dr. Karl Kopiske, Zhanna Borodaeva*
4:30pm	Lab tour project C02 *Dr.-Ing. Philipp Klimant, Sven Winkler*
5:00pm	*Coffee break /informal virtual meetings*
5:15pm	Small Group discussion of research gaps and methodological challenges
6:15pm	Presenting results from small group discussions
7:00pm	*Wrap up and Informal virtual meetings*

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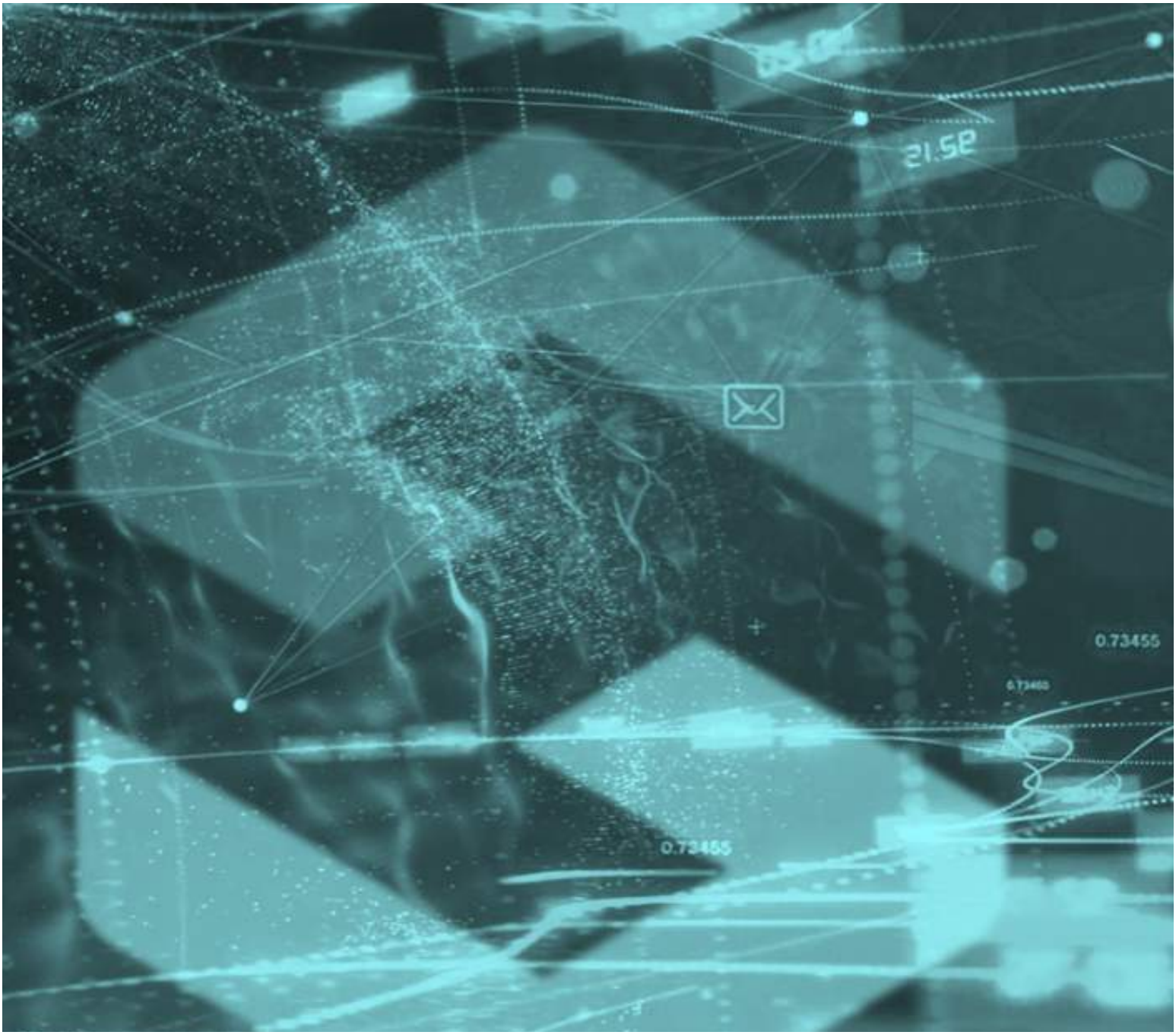

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