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A Dagstuhl Seminar Looks beyond Virtual and Augmented Reality

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In early February 2017, we—along with Anind Dey from Carnegie Mellon University, Jonna Häkkilä from the University of Lapland, and Jun Rekimoto from University of Tokyo—organized a five-day seminar to discuss the future of interactive media. Thirty researchers from Europe, Asia, and the US gathered in picturesque Dagstuhl, a small village in rural Germany, to rethink virtual and augmented reality (see the sidebar). Schloss Dagstuhl, a nonprofit center for computer science research, hosted the seminar, which was motivated by the third wave of VR and AR technologies we're currently witnessing. These technologies are the result of researchers broadly looking into VR and AR again, focusing on topics ranging from using AR to mitigate skills gaps[1] and understanding user interaction with commercial AR games, to using focus depth as an input modality for VR,[2] understanding the effect of gender in VR,[3] and using sensory augmentation in cars.[4]

The goal of the seminar was to take a step back from technical research to look at the fundamental aspects of interactive media. Sharing experiences and knowledge has always been essential for human development, enabling empathy and the transfer of skills. Throughout history, humans have transitioned from oral traditions to cultures of writing. The ongoing digital revolution is removing hurdles to sharing knowledge and experiences. For example, people can now store 24/7 video recordings of their lives, creating massive collections of data. However, this can actually make it even more challenging to share experiences and knowledge with others in meaningful ways.

We need to rethink and redefine experience sharing and skill transfer in light of current technological advances, including affordable consumer-grade VR and AR systems, new sense-sharing technologies (focused on eye gaze, haptics, odors, and so on), and devices offering real-life tracking of physical and cognitive activities and emotional states. At the same time, we must account for research in the fields of cognitive science, education, and psychology, which is providing us with an increased understanding of individual and group behaviors and of empathy and the fundamentals of learning.

Hands-On Workshops

The seminar featured initial talks by all attendees, each of whom provided an overview of his or her work and vision related to interactive media. In addition to several breakout sessions, the seminar schedule included two hands-on workshops on novel experience-sharing technologies.

Electric Muscle Stimulation

Current VR technologies focus on vision and sound, but achieving better immersion will require haptic feedback. Electric muscle stimulation (EMS) is a novel mechanism for providing haptics beyond traditional VR and AR applications (see Figure 1). However, it's currently difficult to prototype EMS-based systems, because there's a lack of hardware, software, and expertise.

Pedro Lopes (Hasso Plattner Institute, Potsdam) introduced us to his research and open source effort to make EMS more accessible for research and development.[5] In this hands-on workshop, we were introduced to the basics of EMS usage and could try application ideas with a simple open source setup (http://plopes.org/ems).

Superception

Shunichi Kasahara (Sony's Computer Science Laboratory) introduced the term *superception,* which unites "super" and "perception," similar to how he aims to unite real and artificial

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Seminar Participants

Following is the complete list of the participants (see Figure A for a group photo).

- Susanne Boll, University of Oldenburg
- Cedric Carême, Takram Design Engineering
- Ashley Colley, University of Lapland—Rovaniemi
- N. Chloe Eghtebas, University of Stuttgart
- Hans-Werner Gellersen, Lancaster University
- Nitesh Goyal, Cornell University—Ithaca
- Scott Greenwald, MIT
- Masahiko Inami, University of Tokyo
- Shunichi Kasahara, Sony CSL—Tokyo
- Gudrun Klinker, Technical University of Munich
- Pedro Lopes, Hasso Plattner Institute
- Stephan Lukosch, Delft University of Technology
- Joachim Meyer, Tel Aviv University
- Florian Michahelles, Siemens
- Yun Suen Pai, Keio University
- Thies Pfeiffer, Bielefeld University
- Yannick Prié, University of Nantes
- Enrico Rukzio, Ulm University
- Thad Starner, Georgia Institute of Technology
- Yuji Uema, J!NS—Tokyo
- Kaisa Väänänen, Tampere University of Technology
- Dan Witzner Hansen, IT University of Copenhagen
- Katrin Wolf, HAW—Hamburg
- Eva Wolfangel

Figure A. Researchers gathered in Dagstuhl for a five-day seminar on the future of interactive media.

perception in his work. He presented examples that include reproducing perceptions and connecting human perceptions through head-worn fisheye cameras and head-mounted displays. Using the cameras and displays, users can immerse themselves in four different views of the world. Kasahara also showcased his recent work, which creates the perception of temporal deformation of the user's own body in VR by introducing tracking delays or predicting the user's movement.[6] In a shared experience, groups experienced the "parallel eyes" system that lets users see three other perspective videos as well as their own perspective video through head-mounted displays (see Figure 2).[7]

In the future, we will see systems that not only digitally alter our perception of reality but also provide entirely new abilities that are tightly integrated into our perceptual and motor system. We will be able to zoom into a scene with just a thought or the blink of an eye, fading out parts of our physical environment to focus on a task or instantly absorb a new language, for example.

Figure 1. Hands-on electric muscle stimulation. Pedro Lopes introduced his open source effort to make EMS more accessible for research and development. In this hands-on workshop, he introduced the basics of EMS usage.

Figure 2. Experiencing Shunichi Kasahara's "parallel eyes" system, which lets users view multiple perspectives through head-mounted displays.

Panel Discussions

The seminar also had three panel discussions, led by senior researchers on human-computer symbiosis, human augmentation, and enabling technologies.

Human-Computer Symbiosis

Reflecting on human-computer symbiosis, Susanne Boll (University of Oldenburg) asked for research into transferring skills to enable laypersons to carry out complex actions on the spot. As an example, she described a scenario in which a medical emergency occurs in a remote place and an untrained person performs medical treatment through skill transfer. The technical foundation for such a transfer will require better networked sensors, better reasoning enabled through AI, and full-body VR and AR complemented through full-body actuation. Kaisa Väänänen (Tampere University of Technology) asked if the technology should focus on human-human—rather than human-computer—symbiosis. In particular, she brought up self-symbiosis and challenged researchers to develop a superhuman ability that lets you empty your own mind and read the minds of others. Hans Gellersen (Lancaster University) focused on empathy as a "superpower"—that is, the ability to transfer your point-of-view to somebody else.

After discussing human-computer symbiosis with the audience, Jonna Häkkilä (University of Oulu) divided the panelists into two groups and asked two controversial questions: Should we replace politicians with artificial intelligence, and should we live with embodied avatars of our ancestors in the future? Each group argued for or against the propositions, resulting in lively discussions.

Human Augmentation

In a panel on human augmentation, Katrin Wolf (Hamburg University of Applied Science) shared her perspective on sensory augmentation and showed examples of her work on sensory illusion. During the panel discussion, she highlighted that humans should stay in control of the level of augmentation. Devices that enable superhuman hearing abilities, for example, must enable users to determine the level of ability, ranging from "superhearing" ability to blocking the surrounding soundscape. Regarding esthetical questions on human augmentation, she pointed out that technology augmentation currently viewed as uncanny might be considered fashionable in the future. For example, the third ear surgically attached to the arm of performance artist Stelarc is still considered disgusting by many (http://stelarc.org), but it might be more acceptable in the future.

Masahiko Inami (Tokyo University) showed work from his lab and his driving vision that aims to go from prosthesis to augmentation. According to Inami, technical evolution will eventually surpass human evolution. Showing work that equipped users with additional limbs, he asks how we can control the extra abilities.

Thad Starner (Georgia Tech and Google) looked at the temporal dimension of human augmentation. He charted the space from passive haptic learning with a delay of hours to direct control of the human body by machines with delays less than a millisecond. According to Starner, the only limitation of augmentation is the human body's brain and nervous system.

The discussion with the audience circled around major challenges that a symbiosis of humans with computers imposes. Audience members asked if augmentation should always add to perception or if it should also reduce experiences. The ability to transmit and share senses could ultimately lead to a hive mind, much like what is depicted by *StarTrek*'s Borg. Crucial is social acceptability, which has thus far prevented the widespread adoption of smart glasses. This topic led to a discussion about fashion and the question of whether devices

that enable superhuman abilities will raise social inequalities to new levels.

Enabling Technologies

The panel on enabling technologies focused on identifying the technical issues, determining how best to give users these new skill sets and experiences, and discussing novel or underused methods.

Enrico Rukzio (Ulm University) started off with a discussion of eyewear and eye-based interactions to determine user states. He then continued, emphasizing scent-based interfaces, which are currently underexplored. Florian Michahelles, from Siemens Corporate Technology, gave an overview about the industry view on enabling technologies, stressing telepresence systems, their progress over the years, and their integration into the future company infrastructure. He also highlighted various open challenges related to telepresence systems. Gudrun Klinker (Technical University of Munich) focused her talk on advances in AR, especially markerless tracking technologies and AR4AR, an automatic calibration system for AR applications. The discussion that followed focused on the usefulness and applicability of scent-based virtual/augmented environments and how such environments might extend the human experience beyond vision and audio.

Outcomes of the seminar include plans of joint research projects and fresh perspectives on the attendees' research agenda. In particular, the field of interactive media must move from a technology-centric perspective that focuses on computational limitations to a human-centric perspective that considers humans' attention as the most scarce resource. With technologies enabling new ways to transfer skills, systems must be tested with real people in real life to identify fundamental challenges and how such systems could transform societies. Augmented sports and superhuman sports are an emerging playground for developing and testing new approaches and technologies. As VR and AR technologies become a part of everyday life, work on ethical implications and social acceptance becomes essential.

With maturing technologies, the community should shift the focus from a very technical approach to a more holistic perspective. Instead of asking how we can build VR and AR systems, we must ask: What do we build? Which new experiences can we create? What are the effects on actual users? How do we cope with users' limited cognitive resources? What will be the implications on the societal level? **MM**

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References

1. S. Yamashita et al., "Demulti Display: A Multiplayer Gaming Environment for Mitigating the Skills Gap," *Proc. 10th Int'l Conf. Tangible, Embedded, and Embodied Interaction* (TEI), 2017, pp. 457–463.
2. Y.S. Pai et al., "Transparent Reality: Using Eye Gaze Focus Depth as Interaction Modality," *Proc. 29th Ann. Symp. User Interface Software and Technology*, 2016, pp. 171–172.
3. V. Schwind et al., "'These Are Not My Hands!': Effect of Gender on the Perception of Avatar Hands in Virtual Reality," to be published in *Proc. 2017 Ann. Symp. Computer-Human Interaction* (CHI), 2017.
4. J. Morita et al., "MRI Overlay System Using Optical See-Through for Marking Assistance," *Proc. IEEE Virtual Reality Conf.*, 2015; doi: 10.1109/VR.2015.7223384.
5. P. Lopes et al., "Hands-On Introduction to Interactive Electrical Muscle Stimulation," *Proc. 2016 CHI Conf. Extended Abstracts on Human Factors in Computing Systems*, 2016, pp. 944–947.
6. S. Kasahara et al., "Malleable Embodiment: Changing Sense of Embodiment by Spatial-Temporal Deformation of Virtual Human Body," to be published in *Proc. 2017 CHI Conf. Human Factors in Computing Systems* (CHI), 2017.
7. S. Kasahara et al., "Parallel Eyes: Exploring Human Capability and Behaviors with Paralleled First Person View Sharing," *Proc. 2016 CHI Conference on Human Factors in Computing Systems* (CHI), 2016, pp. 1561–1572.

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