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Beyond VR and AR: Reimagining Experience Sharing and Skill Transfer Towards an Internet of Abilities

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Abstract

With recent development in capture technology, preserving one's daily experiences and one's knowledge becomes richer and more comprehensive. Furthermore, new recording technologies beyond simple audio/video recordings become available: 360° videos, tactile recorders and even odor recorders are becoming available. The new recording technology and the massive amounts of data require new means for selecting, displaying and sharing experiences. This seminar brought together researchers from a wide range of computing disciplines, including virtual reality, mobile computing, privacy and security, social computing and ethnography, usability, and systems research. Through lightning talk, thematic sessions and hands-on workshops, the seminar investigated the future of interaction beyond virtual and augmented reality. Participants reimagined experience sharing and skill transfer towards an Internet of abilities. We conclude with a set of open and guiding questions for the future of our field.

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1 Executive Summary

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Sharing experiences and knowledge have always been essential for human development. They enable skill transfers and empathy. Over history, mankind developed from oral traditions to cultures of writing. With the ongoing digital revolution, the hurdles to share knowledge and experiences vanish. Already today it is, for example, technically feasible to take and store 24/7 video recordings of one's life. While this example creates massive collections of data, it makes it even more challenging to share experiences and knowledge with others in meaningful ways. Facilitating the third wave of VR and AR technologies we are currently witnessing, researchers started to broadly look at VR and AR again. Topics ranging from using AR to mitigate skills gaps [1] and understanding user interaction with commercial AR games [4], to using focus depth as an input modality for VR [2], and understanding the effect of gender in VR [3]. The goal of the seminar was to take a step back from the technical research to look at the fundamental aspects of interactive media.

A recurring theme in science fiction literature is the act of downloading another human's abilities to one's mind. Although current cognitive science and neuroscience strongly suggest that this is impossible, as our minds are embodied; we believe that skill transfer and effective learning will accelerate tremendously given recent technological trends; just to name a few of the enabling technologies, human augmentation using virtual/augmented reality, new sensing modalities (e.g. affective computing) and actuation (e.g. haptics), advances in immersive storytelling (increasing empathy, immersion, communication) etc.

Ultimately, we believe this will lead to "downloadable" experiences and abilities. The effects will definitely not be instant and it will most likely be very different from the Sci-Fi theme. Yet, these differences are exactly what we want to explore in this seminar. Computer scientists in wearable computing, ubiquitous computing, human computer interaction, affective computing, virtual reality and augmented reality have been working on related topics and enabling technologies for years. However, these developments are disjointed from each other. With this seminar we want to bring them together working in the virtual/augmented/mixed reality, ubiquitous computing, sensing and HCI fields discussing also with experts in cognitive science, psychology and education.

While sharing experiences and knowledge through communication and socializing are a long time focus of various research efforts, we believe it is necessary to rethink and redefine experience sharing and skill transfer in light of the following current technological advances like the following:

1. Affordable Virtual Reality and Augmented Reality systems will become available to consumers in the near future (or already are available).
2. Advances in new sense sharing technologies (e.g. eye gaze, haptics, odors).
3. Advances in real-life tracking of physical and cognitive activities and emotional states.
4. Educators, cognitive scientists and psychologists have now a better understanding of individual and group behaviors, empathy and fundamentals of learning.

The seminar was structured around lightning talks by the participants, two hands-on workshops and three thematic sessions. In the lightning talks, the participants introduced themselves and shared their vision with the group. The first hands-on workshop by Shunichi Kasahara introduced the term Superception and showcased prototypes in this domain. The second workshop organized by Pedro Lopes enabled participants to experiment with electrical muscle stimulation by connecting off-the-shelf devices to embedded systems. Three days of the seminar started with thematic sessions run by one of the organizers. The sessions explored the future of human-computer symbiosis, human augmentation, and enabling technologies.

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2 Table of Contents

3 Overview of Talks

3.1 Towards Unremarkable Use of Augmented and Virtual Reality

Ashley Colley (University of Lapland, FI, Ashley.Colley@ulapland.fi)

Augmented Reality (AR) is currently taking its first real steps out from controlled laboratory environments into the wild. The global PokemonGo phenomena in the summer of 2016 raised questions related to the definition of AR. Rather than focusing on visual aspects, as highlighted by Azuma's definition of AR, e.g. "...registered in 3D", for many users the perception of the real world overlaid with a layer of virtual content was the dominant perception. Study of PokemonGo revealed that location based advantages in the real world were transferred to the virtual content [1]. The smartphone has become the current de facto method of AR browsing in the wild, based on the suitability of their features such as high resolution camera, GPS and inertial sensors. However, smartphones were not designed with the AR browsing task in mind, and this results in a less than optimal user experience [2]. One approach when designing the optimal handheld AR browser device is to examine the balance between the goal of Azuma's perfectly aligned virtual and real content, and practical and ergonomic considerations for in the wild usage. By creating a handheld AR browser device where the device's camera is at a 45 degree angle to its display, efficient AR browsing can be achieved without the physical load of holding the device at eye-level as a magic-lens [3]. The next steps in AR should aim to address in-the-wild usage, focusing on the overall user experience, including multi-sensory and social aspects, rather than perfecting the visual experience. At the same time the potential of the virtual world to provide a more equal experience than the real world should be a core tenet directing the evolution of the domain.

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3.2 Augmented Reality for Sensemaking

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Complex world problems of the future will be solved by encouraging collaboration between humans. However, the present VR/AR frameworks lack seamless collaboration frameworks for problem-solving or decision-making between collaborators. Future AR systems will need to be merged into the collaboration technologies' setup to enable such complex tasks without significant cognitive load, yet enhancing task performance. Sharing has been shown to be tricky, especially when required to do so explicitly between collaborators. Implicit sharing has been shown to improve task performance. Future AR systems can benefit from implicit sharing of information synchronously or asynchronously. This would enable collaborators to leverage peripherally shared information. Alternatively, AR systems may play not just a passive role, but an active role too. Identifying and sharing relevant information, embedded in the real world actively to encourage awareness is what I anticipate the future of AR to look like. The challenges that prevent us from reaching this goal, include technical challenges like the lack of an AR equipped environment, but also include socio-technical challenges that assume that future users will be expert at using AR systems, and subsequently will use the systems ethically.

3.3 Involving Users in Future Visions

Jonna Häkkilä (University of Lapland, FI, Jonna.Hakkila@ulapland.fi)

We live in a world where the technological innovations are advancing in a rapid speed. Mobile technology has fundamentally changed our everyday life during the past two decades, and we are now able to access other people, information and different types of services whenever we wish. Now the smart phone is the primary general ICT tool and user interface (UI) while mobile, but next steps are already emerging to the use for large audiences. Wearable technologies have already been adopted by masses of people e.g. in the form of activity trackers, and form factors such as smart watches and bracelets are a commodity. AR and VR technologies have also become better affordable for developers and consumers e.g. for gaming, and although not yet visible on the streets, products in this frontier are emerging.

When developing novel technology solutions that are aimed for large user groups, it is important to pay attention to the usability and user experience (UX) with the devices and applications. Ease of use, ergonomics, and aesthetic design are factors, which affect to the user's interest and engagement with the technology. The social acceptability should not be neglected, as privacy concerns and embarrassment when using unusual gadgets in public can greatly affect to the adoption of new technologies. The focus on ubiquitous computing research has so far been heavily on the technology side instead of user experience [4]. While technology has become more mature and miniaturized, the possibilities to explore different design aspects have grown. My research addresses the user experience design and user centric design of future technologies. Through design, we can communicate technology visions to large audiences and create concepts, which appeal to people as potential future garments or products, not just as engineering demos. An example of such is Solar Shirt design concept and prototype, an environmental awareness wearable utilizing printed electronics solar cells and flexible displays are part of the design of a fashion garment [3]. User experience design can also seek novel materials for interaction. In BreathScreen concept and prototype shows how a situated fog screen is created from the breath or smoke around the user, forming an ephemeral UI [1]. This kind of novel interfaces can be used to augment us and our immediate surroundings in a pleasant and experience rich manner. In my research I also wish to highlight the importance of evaluating novel technologies in-the-wild with users, as e.g. in our experiment of trying out skiing and snowboarding in VR in-the-wild, i.e. in a downhill slope [2]. By exposing the concepts to a real life use context, we gain valuable insights of its requirements and challenges.

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3.4 When Information is not Scarce

Niels Henze (University of Stuttgart, DE, niels.henze@vis.uni-stuttgart.de)

We currently witness another wave of augmented- and virtual reality research. For the first time, augmented- and virtual reality technologies become not only widely available to consumers but also adopted by them. In the previous weave, one of our research focus was highlighting content that is currently not in the user's field of view by developing and evaluating off-screen visualisations [1, 2]. In the last years, we not only witness improvements in augmented- and virtual reality technologies, but also face a dramatic change of how humans and computers interact. The classic human-computer interaction principle was based on the assumption that users should start with an action and the computer responses with a reaction. We currently see more and more systems that violate this principle. What started with simple notifications about incoming emails developed into a whole notification ecosystem (see e.g. [3, 4]).

The question today is not how to highlight that more information is available but to support users coping with proactive computing and a large amount of available information. We investigate different directions to support users. In virtual reality, we investigate how virtual representations of the user should be presented to be accepted by users [5, 6]. Regarding notifications, we study how users interact with notifications that are proactively delivered and developed new means to present and manage them [7, 8, 9]. We further investigate approaches that take the user's attention into account when presenting information [10]. Ultimately, it will be necessary to bring the components together and build systems that actively manage the user's attention. Just as computer science developed algorithms to manage other scarce resources such as processing poser and random access memory, we need to develop algorithms that manage human attention.

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3.5 Superception

Shunichi Kasahara (Sony CSL – Tokyo, JP, kasahara@csl.sony.co.jp)

How technologies empower us? How technologies change the human perception? I am right now envisioning a research concept called Super + perception = superception. The word "super" has two meanings : one is to augment, enhance or empower; the other is connection beyond individuals. I am exploring ways to augment and transform our perception by intervening our sensation computationally or connecting multi human perception with technologies. From this point of view, beyond VR and AR means sensory augmentation and substitution beyond visual related technologies. In a broader sense, emergence of sensory related technologies enable us to access the internal data of our body i.e. human perception. With these technologies, we will be able to engineer our perception.

In my research, I explore ways to produce Superception according to three strategies: reproducing perception, using illusionary perception computationally and connect multiple perception and sensation. In this workshop, I presented Parallel Eyes, which is a system that connect multiple first person view so that four person can see the shared first person view as well as their own.

Engineering for accessing digital data using computer and performing real world functions will be interpreted as "Engineering for interface" which includes AR interface. On the other hand, the approach of Superception to control human perception and sensation using sensing technology and virtual reality can precisely control human inputs and outputs, termed "Engineering for Perception". I believe that Superception will be a platform for engineering control related to human senses and augmentation of human abilities and perception.

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3.6 AR-ready environments

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Up to very recently, research goals of VR and AR have been rather technology-driven: we need to build machines and devices (displays, sensors) that were fast and precise enough to convey the 3D illusion of perceiving virtual objects in 3D environments. Newest technology (HMDs, optical and time-of-flight sensors) is on the verge of passing fundamental thresholds related to human sensing limitations. Going beyond these threshold means creating user experiences suitable for real applications. Research transforms from considering technical aspects towards considering a human perspective: we are surrounded by masses of virtual information. How can computers help us perceive and interact with this information?

At the Technical University Munich, we are developing a framework for Ubiquitous Augmented Reality, which provides users with AR-services wherever they go via ubiquitous tracking, ubiquitous presentation and ubiquitous interaction. This lays the foundation towards creating, evolving and testing many different approaches to have users experience augmented worlds. Users can interact with information based on technology provided by complex hybrid combinations of mobile and stationary devices installed in an AR-ready world.

3.7 Towards Engaging Augmented Reality Environments

Stephan Lukosch (TU Delft, NL, s.g.lukosch@tudelft.nl)

Orson Scott Card impressively shows the effect of high fidelity in simulation games in his novel Ender's Game [3]. The main actor Ender and his team believe they are playing a training simulation game for fighting a war on an alien race. In the end, it becomes clear that Ender was in fact commanding the real fleet through the game, attacking and finally extinguishing the alien race. Tad Williams describes in his saga Otherland [20, 21, 23, **?**] a future world with a widespread availability of full-immersion virtual reality [11] installations. These installations allow people to access an online world, called simply 'the Net'. Within the Net, a group of people aims to achieve immortality. In his novel Rainbows End [19] Vernor Vinge describes how the main character Robert Gu is slowly recovering from Alzheimer's disease due to medical advances in the future. While recovering, former technophobe Robert adapts to a changed world in which almost every object is networked and the use of augmented reality [1, 2] is normal. Humans interact within augmented reality by wearing smart clothes and contact lenses that can overlay the physical environment with computer graphics. In Rainbows End [19], augmented reality is used for various purposes, e.g., large-scale commercial gaming areas, supporting maintenance workers with blueprints of machines or buildings, communication with virtual avatars and diagnostic purposes in medical settings.

Science Fiction authors Orson Scott Card, Tad Williams and Vernor Vinge forecast a vision of engaging augmented and virtual reality environments that current research is already addressing. Feng et al. study the effect of wind and vibrations on orientation in virtual environments [8]. Narumi et al. consider the effect of artificial smell and augmented reality on taste [12]. There has been quite some research on introducing smell into movie theaters and television [9] and even more research on haptic feedback [17]. One of the most difficult aspects to reproduce, however, is a realistic interaction with other (real or virtual) humans. Olson and Olson [13, 14] analysed technology support for virtual co-location. They came to the conclusion that distance matters and that the analysed technology is not mature enough to enable virtual co-location. Olson and Olson stated that even future technology will struggle to enable virtual co-location. In their opinion, providing awareness among co-workers and enabling co-reference as well as spatial referencing will remain a challenge. Complex problem solving still requires a team of experts to physically meet and interact with each other. Then, the identification of the problem and the creation of a shared understanding are major challenges for efficiently solving a problem [15]. Typical scenarios are, e.g., solving complex construction problems, training the usage of complex machinery, analysing complex situations in emergency services or diagnosing complex medical situations. Unfortunately, it is not always possible to bring a team together to handle a complex situation. This is due to experts' availability, critical timing issues or accessibility of a location. While in the novel Rainbows End [19], such situations are supported with augmented reality technology, current technology is not yet there.

We have taken first steps towards the combined visions of Orson Scott Card, Tad Williams and Vernor Vinge on highly engaging augmented reality environments. We showed [16, 5, 6] that virtual co-location can enable experts at a distance to interact with investigators on a crime scene and jointly perform investigation tasks. We further showed that such interaction as well as the exchange of information in augmented reality increases the situational awareness of teams [10]. With a game on jointly building a tower out of virtual blocks [7], we showed that virtual co-location can be used to collaboratively solve complex spatial problems. Further, we have combined serious games in augmented reality with sensors for motion tracking [4, 18] to create novel and engaging approaches for human motor function assessment. In future research, we will explore how to address all human senses as described by Tad Williams. Here, we are especially interested in the effect on engagement and the training outcomes when using serious games in augmented reality for training complex scenarios or learning complex tasks. We will continue our research on how to enable realistic interaction between local users as well as remote users in augmented environments and on how to enable interaction between real and virtual objects. Addressing these research issues will allow us to go beyond current VR and AR environments and create engaging augmented reality environments for future experience sharing and skill transfer.

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3.8 Cognitive Engineering for VR and AR applications

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Much of the research on AR and VR focuses on technological development, but increasingly it becomes possible to deploy solutions for actual use. These possibilities raise the question how one should design VR and AR to fit into specific systems and contexts. The approaches developed in cognitive engineering and human performance modeling can help us determine the optimal design of systems for a given context. It is possible to address many problems with these modeling methods, such as:

1. What is the required level of reality? For some purposes, a very crude, low-resolution imagery may be sufficient, while in other contexts, an application can only function if it responds extremely fast and has very high graphic quality. For instance, in research on driving one can use low-resolution PC-based displays of the roadway to study the effects of in-vehicle devices on driver distraction (e.g., [1]). In contrast, to study driver responses to vehicle dynamics, one needs very advanced moving-base simulators, or one may actually need real vehicles.
2. What are the required and what are optimal properties of information displays (such as alerts) in AR? The design of these systems needs to balance the possibility for alarm fatigue (the cry-wolf syndrome) resulting from excessively frequent alerts, as opposed to the possibility of complacency, where people rely very strongly on alerts and fail to monitor other information [2].
3. What settings of the system can users adjust correctly and what settings should be determined for the user? Often users may not have the necessary information to decide on the correct setting (such as a threshold) [3]. The use of models for these (and related) issues can help in all stages of the system life cycle, from the initial specifications, over the design, the deployment, up to the evaluation of the functioning system.

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3.9 Digital Humanities

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I am a professor of computer science at the University of Nantes in France. I am currently involved in the installation of the University into a new building dedicated to research, teaching and innovation around Digital Culture, with interdisciplinarity at its core. There will also be an associated masters program in relation with schools of Art, Design, and Communication. I began working on ontological and document engineering and I moved towards HCI and data visualization, and my motto has now evolved to "computer science & interdisciplinary". I have been working in the field of digital humanities, with current projects in science and technology studies, and in learning analytics [1]. I have also worked in trace technology, doing video active reading and annotation systems such as the open source video annotation software Advene [2] as well as trace-based reflective systems [3, 4]. I have lately turned toward visual analytics, and have several project related to interactive and progressive mining [5], as well as VR-based immersive analytics. I have also been interested into studying activity development [6]; both from a 3rd person and a 1st person perspective (micro-phenomenology), and have recently began working with psychotherapists around tdcs and VR.

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3.10 Physiological Signal-Driven Virtual Reality in Social Spaces

Pai Yun Suen (Keio University, JP, yspai1412@gmail.com)

VR and AR has been progressing at a rapid pace, and even though current mechanics are not perfect, such as locomotion [1] or haptic systems, its continuous evolution requires further design considerations for new interaction mechanics. One of the key issues to consider is for a future where VR and AR are being used anywhere, anytime. Foreseeing such a future in the next 10 years is a very likely outcome, and new issues will arise from such a usage. For instance, the interaction that is often accustomed for VR; reaching out to grab and object, performing wide gestures, etc. These interaction methods are immersive, but highly unlikely to be usable in public areas. Prior to gestures, buttons on controllers were the traditional input mechanic, but this on the other hand suffers from realism and to a higher degree, a cause for simulation sickness.

To accommodate these social spaces and proxemics, the idea of subtle input and subtle interactions are a worthwhile investigation. This refers to inputs and interactions that are unobtrusive and won't annoy others. Firstly, it is important to determine the definition of a social space. What are the physical constrains that we face in our daily life when navigating in the physical environment? In proxemics, human space can be categorized under 4 types; intimate, personal, social and public. Furthermore, depending on the scenario, these spaces have further constrains. For instance, standing in the bus requires us to be holding a handle for safety, meaning interactions are preferably hands-free. The second issue is concerning the preferred input methods by the users. Physiological sensing [2] is an interesting form of input because it provides both explicit and implicit data regarding our current physiological state, to be used as a mechanic in VR or AR. Input methods such as using eye gaze [3, 4], muscle contraction, or even brain interface are worth investigation to determine the users' preferences. The third issue then would be to determine the appropriate interaction mechanic for these sensing methods to remain subtle and unobtrusive. For example, eye gaze is suitable for selection in a virtual environment, but less preferable for activation to avoid straining the eye.

The concept of social acceptance toward VR being "anytime, anywhere" actually encompasses several other considerations that are also worth mentioning, such as how the difference in culture may impact the kind of sensing methods that are allowed to be used in public spaces. Furthermore, a solution is required for interactions in the virtual word to simply "blend" into real world interactions. A simple example would be if we were required to tie a shoe lace while wearing a HMD. It would be a hassle to remove the HMD to tie the shoe lace before putting it back on. Finally, the overall concept of subtle interaction has an important design consideration with relation to VR and AR; it will undoubtedly sacrifice immersion at the expense of subtleness. All these issues need to be addressed to welcome an era of VR and AR being anytime, anywhere.

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3.11 J!NS MEME – Unobtrusive Smart Eyewear

Yuji Uema (J!NS – Tokyo, JP, yuji-uema@jin-co.com)

JINS CO., LTD released a smart eyewear, JINS MEME in November 2015. It is our new challenge to the field of wearable computing and VR/AR. We initially targeted all consumer but encountered many difficulties regarding the design and benefit of it.

The first issue is social acceptance. Since JINS is an eyewear company, we know that design of eyeglasses matters the most. Therefore, we put our maximum effort to keep JINS MEME hardware looking like a piece of regular eyeglasses. As a result, we designed JINS MEME with bigger temple tips for the battery and electrical circuit. However, we realized that this relatively smaller physical difference compared to regular eyeglasses makes a vast difference in social acceptance. In general, people have accepted and worn eyeglasses more than 700 years. Following this sophisticated design (trend) can be a key factor in social acceptance.

Another challenge is to let people know that we need some practice to get accustomed to these technologies. When it comes to wearable devices and AR/VR devices, people typically do not expect a demand for training. This mindset often makes a gap between user's expectation and benefit of using these technologies. As a result, it sometimes create a negative impression on them.

3.12 Human-centered design of augmentations of social and calm interactions

Kaisa Väänänen (Tampere University of Technology, FI, kaisa.vaananen@tut.fi)

In this research community we can develop advanced technologies that will augment our senses and activities in various life contexts. We should design these augmentations keeping in mind the consequences that these augmentations may have to individuals' life experiences, to their social relationships and even to the humankind (see Figure 1).

An important perspective is that of using augmentation technologies to support social relationships [1]. Such augmentations can enhance sociability remotely or locally. Technologies need to be built for different modalities that enhance both bodily and mental connectedness of people. Studies of social acceptability of the technologies in the real contexts of use are also needed.

Another use of augmenting technologies is to help people to calm down in their hectic everyday lives. One way of supporting this is the actual opposite of adding information to the real world: Diminished reality can remove clutter from the user's surroundings and help people focus on the essentials and also to calm down.

Human-centered design with appropriate user experience goals [2] is a fruitful starting point for such technologically novel augmentations.

Figure 1 Human-centered design ignite talk by Kaisa Vaananen.

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3.13 Socially Acceptable Smart Cameras and AR Glasses

Katrin Wolf (Hamburg University of Applied Sciences – Hamburg, DE, Katrin.Wolf@haw-hamburg.de)

Wearable cameras are nowadays used for adding digital information to our environment through augmented reality (AR) as well as for life logging [1]. We know that lifelog images look best when the camera is worn on the user's head, for example through embedded into glasses [2]. Due to possibilities of automated face and location recognition [3], wearable cameras promise to provide digital information about people we see, meet and talk to, which will be possible right at the moment our wearable camera is capturing them. The lack of information about what smart glasses show about us during a conversation or if the device is recording us while talking makes many people feel uncomfortable when users of wearable cameras and smart glasses are around. With respect to the bystanders' perspective on being captured and computational analyzed, my current research is dedicated to better understand how wearable cameras and their UI should be designed to ensure privacy, to not harm the bystanders' right to be aware what users see about us, to provide ways to object being captured, and in general to foster social acceptability of wearable cameras and AR glasses.

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4 Workshops

We organized two workshops on hot enabling technologies in VR and AR, to give participants hands-on experiences for later ideation sessions.

4.1 Electric Muscle Stimulation Workshop

Organizer: Pedro Lopes (Hasso Plattner Institute, Potsdam, pedro.lopes@hpi.de)

Current virtual reality technologies focus on vision and sound. However, for better immersion, haptic feedback is needed. Electric Muscle Stimulation (EMS) is an interesting novel mechanism to provide haptics beyond traditional VR and AR applications[1]. Currently, it is still difficult to prototype EMS based systems, as there is a lack of hardware, software and expertise. Pedro Lopes from the Hasso-Plattner-Institut introduced us to his research and open-source effort to make EMS more accessible for research and development [Lopes 2016]. In this hands-on workshop, we first got an introduction into the basics of EMS usage and tried application ideas with a simple open source setup (http://plopes.org/ems/).

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4.2 SuPerception Workshop

Shunichi Kasahara from Sony's Computer Science Laboratory introduced the term SuPerception which unites super and perception just as he aims at uniting real and artificial perception in his work. He presented examples that include reproducing perceptions and connecting human perceptions through head-worn fisheye cameras and head-mounted displays. Combining the two concepts he enables to be immersed into someone else. Kasahara also showcased his recent work that creates the perception of temporal deformation of the own body in virtual reality by introducing tracking delays or generating prediction of the user's movement[1]. In a shared experience, groups used the parallel eyes system that enables to see three other's perspective video as well as the own perspective through head mounted displays[2].

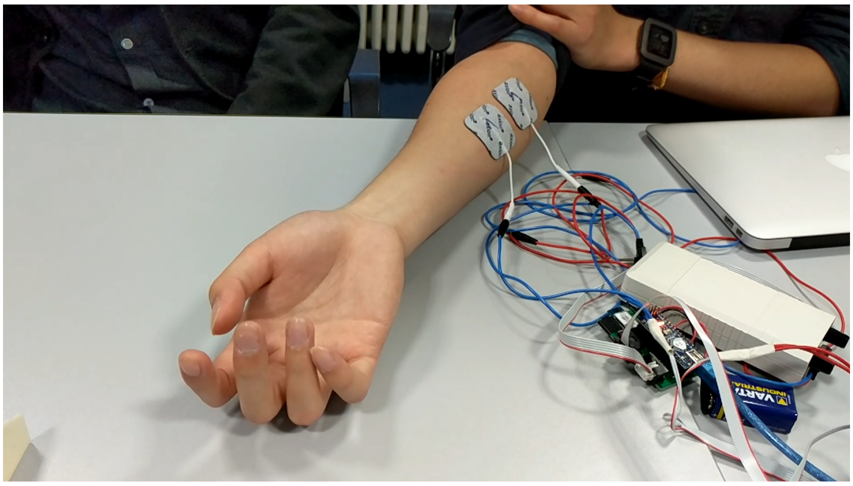

Figure 2 Participants experiencing EMS.

In the future we will see systems that not only digitally alter our perception of reality but provides 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 instead of learning languages just know them.

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5 Thematic Sessions

5.1 Human-Computer Symbiosis

Facilitator: Jonna Häkkilä (University of Lapland, Finland, jonna.hakkila@ulapland.fi)

This thematic session focused on the symbiosis of human and computer. The session started with inspiration talks, and continued with an interactive panel session.

5.1.1 Inspiration Talks

The inspiration talks of the session were given by Susanne Boll, Kaisa Väänänen, and Hans Gellersen, who all gave a short talk of an imaginary superpower of their choice. This was then discussed in respect to the possibilities of human-computer symbiosis. Reflecting on human-computer symbiosis, Susanne Boll asked for the ability to transfer skills to enable people to carry out complex actions on the spot. As an example, she described the scenario of a medical emergency in a remote place, where one was enabled to become a superhero with rescue skills. Through skill transfer, everyone could be enabled to perform a complex

Figure 3 Parallel Eyes session.

medical treatment. As the technical foundation she called for better networked sensors, better reasoning enabled through AI as well as full-body AR, and VR complemented through full-body actuation. Kaisa Väänänen posed the question if technology should focus more on connecting humans through technology instead of human-computer symbiosis. She also challenged the audience by posing self-symbiosis as a challenge. She demanded a superhuman ability that enabled to empty one's own mind, as well as the ability to read the other's mind and body language. Hans Gellersen focused on empathy as a super power. The ability to transfer your point-of-view to somebody else would improve the communication between people and prevent conflicts.

5.1.2 Panel

After discussing human-computer symbiosis with the audience, a facilitated theme panel was organized. Two groups were asked to come forward as panelist teams: Team A (Niels Henze, Susanne Boll, Hans Gellersen) and Team B (Enrico Rukzio, Kaisa Väänänen, Anind Dey). The facilitator of the panel (Jonna Häkkilä) asked the group to discuss controversial questions, and Team A had to always oppose the idea, whereas Team B had to argue for the idea. Both teams had a few minutes to come up with their arguments, and in the meanwhile, the people in the audience had a chance to discuss about the topic with the people next them. The questions or statements given to the panelist teams were as follows: a. In the future, are we able to marry robots? b. In the future, should we be able to replace politicians with AIs? c. In the future, should we have extra robotic arms implanted on us? d. In the future, also my ancestors (like, great-grandfather) will live in my house as (embodied?) avatars. The two teams arguing in favor or opposing the idea resulted very lively discussions touching e.g. social and ethical aspects of human-computer symbiosis.

Figure 4 Panel discussion between Team A and Team B.

5.2 Human Augmentation

Facilitator: Niels Henze (University of Stuttagart, Germany, niels.henze@vis.uni-stuttgart.de)

5.2.1 Inspiration Talks

The inpiration talks in this session were given by Katrin wolf, Mashiko Inami and Thad Starner (see Figure 5), and were followed by a panel discussion with the presenters. Katrin Wolf shared her perspective on sensory augmentation and showed examples of her work on sensory illusion. During the panel discussion, she highlighted, e.g., that humans should stay in control of the level of augmentation. Devices that enable superhuman hearing abilities, for example, must enable users to decide which level of the ability was wanted, from superhearing abilities to blocking the surrounding soundscape. Regarding esthetical questions on human augmentation, she pointed out that technology augmentation that was perceived as uncanny today might be the fashion in the future. For instance, while the third ear the performance artist Stelarc surgically attached to his arm is still considered repelling by many, it might be acceptable in the future. Masahiko Inami showed work from his lab and his driving vision that aims to go from prosthesis to augmentation. Inami draw the link between human evolution which is surpassed by technical evolution. Showing work that equipped users with additional limbs he asked how to control the extra abilities. Thad Starner from Georgia Tech and Google addressed the temporal dimension of human augmentation. He charted the space from passive haptic learning with a delay of hours, to the direct control of the human body by machines with delays less than a millisecond. The main limitation for the augmentation was considered to be the human brain and nervous system itself.

5.2.2 Discussion

The discussion with the audience circled around major challenges that a symbiosis of humans with computers impose. It was asked if augmentation should always add to perception or if it should also reduce experiences. The ability to transmit and share senses on a large scale was discussed, and it was hihglighted that this could ultimately lead to a hive mind

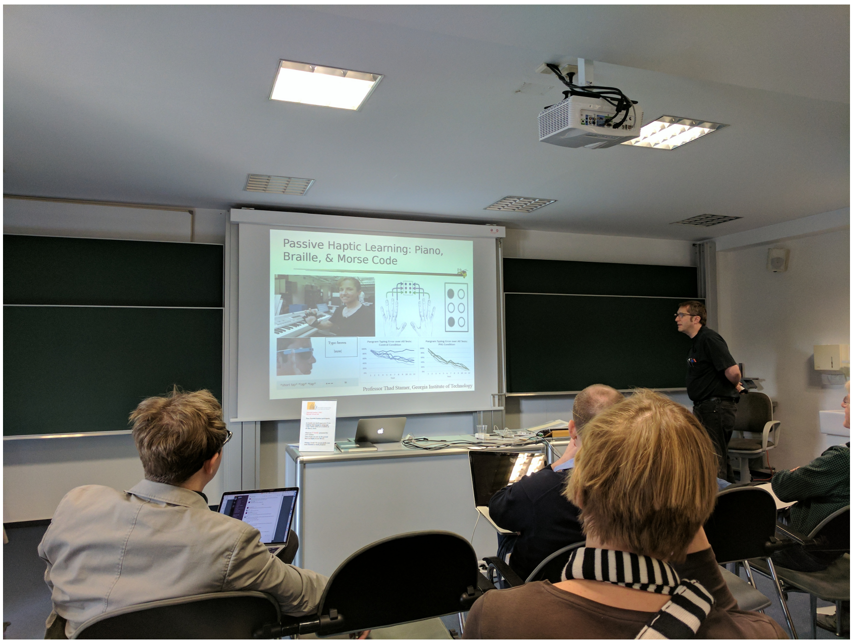

Figure 5 Passive haptic learning by Thad Starner.

society, much like what is depicted by StarTrek's Borg. Social acceptability was seen as a crucial element to lead to or prevent the adoption of the technology. This led to a discussion about fashion and the question if devices that enable superhuman abilities will raise social inequalities to new levels.

5.3 Enabling Technologies

Facilitator: Anind Dey (Carnegie-Mellon University, USA, anind@cs.cmu.edu)

5.3.1 Inspiration Talks

The inpiration talks in the beginning were given by Enrico Rukzio, Florian Michahelles, and Gudrun Klinker. The session on Enabling Technologies focused on the technical issues, means of giving users new skills and experiences, as well as discussing novel or underused methods. Enrico Rukzio started off by discussing on eyewear and eye-based interactions to determine user states. He then continued with scent-based interfaces, which are so far underexplored. Florian Michahelles gave an overview about the industry view on enabling technologies stressing telepresence systems, their progress over the years, and their integration in the future company infrastructure (see Figure 6). He also highlighted the still open challenges related to them. Gudrun Klinker focused on the advances in augmented reality, especially markerless tracking technologies and AR4AR, an automatic calibration system for AR applications. The following discussion focused on the usefulness and applicability of scent-based virtual/augmented environments heading towards more general technologies about extending the human experience away from vision and audio.

Figure 6 View on current industries by Florian Michahelles.

Figure 7 Bodystorming session.

5.3.2 Bodystorming

Followed by the inspiration talks and discussion, an interactive session utilizing a bodystorming co-design method was conducted (see Figure 7). The session involved participants, working in groups, to come up with a future scenario, where technology enabled 'superhuman' power was used in a social setting. These scenarios were then acted by the groups whilst others in the audience. The presented scenarios included, e.g., communicating with thoughts whilst in a business meeting, and semi-automatic behaviour adaptation into the social context.

6 Outcomes

Outcomes of the seminar include plans of joint research projects and fresh perspectives on the attendees' research agenda. In particular, the seminar concluded with a set of challenges for future work:

- Augmented and Virtual Reality research must move from a technology-centric perspective that focuses on computational limitations to a human-centric perspective that considers humans 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.
- Future work must consider a holistic perspective on the user incorporating body and mind. Ultimately, we need methods for describing, visualizing, and interpreting human movement.

With maturing technologies, the community must 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? Participants already started to address these questions. We are looking forward to exciting work that currently emerges from the seminar.

Participants

- Susanne Boll
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