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HCI
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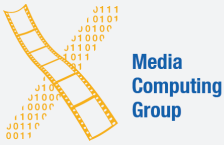

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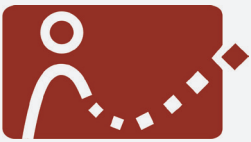

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Adding Force Feedback to Mixed Reality Experiences and Games using Electrical Muscle Stimulation

Pedro Lopes (Hasso Plattner Institute), Sijing You (Hasso Plattner Institute), Alexandra Ion (Hasso Plattner Institute), and Patrick Baudisch (Hasso Plattner Institute)

We present a mobile system that enhances mixed reality experiences with force feedback by means of electrical muscle stimulation (EMS). The benefit of our approach is that it adds physical forces while keeping the users' hands free to interact unencumbered—not only with virtual objects, but also with physical objects, such as props and appliances. We demonstrate how this supports three classes of applications along the mixed-reality continuum: (1) entirely virtual objects, such as furniture with EMS friction when pushed or an EMS-based catapult game. (2) Virtual objects augmented via passive props with EMS- constraints, such as a light control panel made tangible by means of a physical cup or a balance-the-marble game with an actuated tray. (3) Augmented appliances with virtual behaviors, such as a physical thermostat dial with EMS-detents or an escape-room that repurposes lamps as levers with detents.

Grafter: Remixing 3D Printed Machines

Thijs Jan Roumen (Hasso Plattner Institute), Willi Müller (Hasso Plattner Institute), and Patrick Baudisch (Hasso Plattner Institute)

Creating new 3D printed objects by recombining models found in hobbyist repositories has been referred to as "remixing." In this paper, we explore how to best support users in remixing a specific class of 3D printed objects, namely those that perform mechanical functions. In our survey, we found that makers remix such machines by manually extracting parts from one parent model and combine them with parts from a different parent model. This approach often puts axles made by one maker into bearings made by another maker or combines a gear by one maker with a gear by a different maker. This approach is problematic, however, as parts from different makers tend to fit poorly, which results in long series of tweaks and test-prints until all parts finally work together. We address this with our interactive system grafter. Grafter does two things. First, grafter largely automates the process of extracting and recombining mechanical elements from 3D printed machines. Second, it enforces a more efficient approach to reuse: it prevents users from extracting individual parts, but instead affords extracting groups of mechanical elements that already work together, such as axles and their bearings or pairs of gears. We call this mechanism-based remixing. In a final user study, all models that participants had remixed using grafter could be 3D printed without further tweaking and worked immediately.

iTurk: Turning Passive Haptics into Active Haptics by Making Users Reconfigure Props in Virtual Reality

Lung-Pan Cheng (Hasso Plattner Institute), Li Chang (Hasso Plattner Institute; ETH Zurich), Sebastian Marwecki (Hasso Plattner Institute), and Patrick Baudisch (Hasso Plattner Institute)

We present a system that complements virtual reality experiences with passive props, yet still allows modifying the virtual world at runtime. The main contribution of our system is that it does not require any actuators; instead, our system employs the user to reconfigure and actuate otherwise passive props. We demonstrate a foldable prop that users reconfigure to represent a suitcase, a fuse cabinet, a railing, and a seat. A second prop, suspended from a long pendulum, not only stands in for inanimate objects, but also for objects that move and demonstrate proactive behavior, such as a group of flying droids that physically attack the user. Our approach conveys a sense of a living, animate world when in reality the user is the only animate entity present in the system, complemented with only one or two physical props. In our study, participants rated their experience as more enjoyable and realistic than a corresponding no-haptics condition.

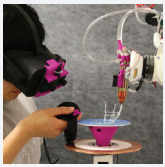
Metamaterial Textures

Alexandra Ion (Hasso Plattner Institute), Robert Kovacs (Hasso-Plattner-Institute), Oliver S. Schneider (Hasso Plattner Institute), Pedro Lopes (Hasso Plattner Institute), and Patrick Baudisch (Hasso Plattner Institute)

We present metamaterial textures - 3D printed surface geometries that can perform a controlled transition between two or more textures. Metamaterial textures are integrated into 3D printed objects and allow designing how the object interacts with the environment and the user's tactile sense. Inspired by foldable paper sheets ("origami") and surface wrinkling, our 3D printed metamaterial textures consist of a grid of cells that fold when compressed by an external global force. Unlike origami, however, metamaterial textures offer full control over the transformation, such as in between states and sequence of actuation. This allows for integrating multiple textures and makes them useful, e.g., for exploring parameters in the rapid prototyping of textures. Metamaterial textures are also robust enough to allow the resulting objects to be grasped, pushed, or stood on. This allows us to make objects, such as a shoe sole that transforms from flat to treaded, a textured door handle that provides tactile feedback to visually impaired users, and a configurable bicycle grip. We present an editor assists users in creating metamaterial textures interactively by arranging cells, applying forces, and previewing their deformation.

RoMA: Interactive Fabrication with Augmented Reality and a Robotic 3D Printer

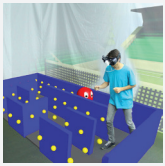
Huaishu Peng (Cornell University, Ithaca, United States), Jimmy Briggs (Cornell University, Ithaca, USA), Cheng-Yao Wang (Cornell University, Ithaca, USA), Kevin Guo (Cornell University, Ithaca, USA), Joseph Kider (University of Central Florida, Orlando, USA), Stefanie Mueller (MIT CSAIL, Cambridge, USA), Patrick Baudisch (Hasso Plattner Institute), François Guimbretière (Cornell University, Ithaca, USA)



We present the Robotic Modeling Assistant (RoMA), an interactive fabrication system providing a fast, precise, hands-on and in-situ modeling experience. As a designer creates a new model using RoMA AR CAD editor, features are constructed concurrently by a 3D printing robotic arm sharing the same design volume. The partially printed physical model then serves as a tangible reference for the designer as she adds new elements to her design. RoMA's proxemics-inspired handshake mechanism between the designer and the 3D printing robotic arm allows the designer to quickly interrupt printing to access a printed area or to indicate that the robot can take full control of the model to finish printing. RoMA lets users integrate real-world constraints into a design rapidly, allowing them to create well-proportioned tangible artifacts or to extend existing objects. We conclude by presenting the strengths and limitations of our current design.

VirtualSpace - Overloading Physical Space with Multiple Virtual Reality Users

Sebastian Marwecki (Hasso Plattner Institute), Maximilian Brehm (Hasso Plattner Institute), Lukas Wagner (Hasso Plattner Institute), Lung-Pan Cheng (Hasso Plattner Institute), Florian Mueller (RMIT University, Merlbourne, Australia), and Patrick Baudisch (Hasso Plattner Institute)



Although virtual reality hardware is now widely available, the uptake of real walking is hindered by the fact that it requires often impractically large amounts of physical space. To address this, we present VirtualSpace, a novel system that allows overloading multiple users immersed in different VR experiences into the same physical space. VirtualSpace accomplishes this by containing each user in a subset of the physical space at all times, which we call tiles; app-invoked maneuvers then shuffle tiles and users across the entire physical space. This allows apps to move their users to where their narrative requires them to be while hiding from users that they are confined to a tile. We show how this enables VirtualSpace to pack four users into 16m2. In our study we found that VirtualSpace allowed participants to use more space and to feel less confined than in a control condition with static, pre-allocated space.

A Bermuda Triangle? - A Review of Method Application and Triangulation in User Experience Evaluation

Ingrid Pettersson (Volvo Cars and Chalmers University of Technology Göteborg), Florian Lachner (LMU Munich), Anna-Katharina Frison (Technische Hochschule Ingolstadt and Johannes Kepler University Linz), Andreas Riener (Technische Hochschule Ingolstadt and Johannes Kepler University Linz), Andreas Butz (LMU Munich)

User experience (UX) evaluation is a growing field with di- verse approaches. To understand the development since previous meta-review efforts, we conducted a state-of-the-art review of UX evaluation techniques with special attention to the triangulation between methods. We systematically selected and analyzed 100 papers from recent years and while we found an increase of relevant UX studies, we also saw a remaining overlap with pure usability evaluations. Positive trends include an increasing percentage of field rather than lab studies and a tendency to combine several methods in UX studies. Triangulation was applied in more than two thirds of the studies, and the most common method combination was questionnaires and interviews. Based on our analysis, we derive common patterns for triangulation in UX evaluation efforts. A critical discussion about existing approaches should help to obtain stronger results, especially when evaluating new technologies.

Empowerment in HCI - A Survey and Analysis

Hanna Schneider (LMU Munich), Malin Eiband (LMU Munich), Daniel Ullrich (LMU Munich), Andreas Butz (LMU Munich)

Empowering people through technology is of increasing concern in the HCI community. However, there are different interpretations of empowerment, which diverge substantially. The same term thus describes an entire spectrum of research endeavours and goals. This conceptual unclarity hinders the development of a meaningful discourse and exchange. To better understand what empowerment means in our community, we reviewed 54 CHI full papers using the terms empower and empowerment. Based on our analysis and informed by prior writings on power and empowerment, we construct a framework that serves as a lens to analyze notions of empowerment in current HCI research. Finally, we discuss the implications of these notions of empowerment on approaches to technology design and offer recommendations for future work. With this analysis, we hope to add structure and terminological clarity to this growing and important facet of HCI research.

Extending Keyboard Shortcuts with Arm and Wrist Rotation Gestures

Daniel Buschek (LMU Munich), Bianka Roppelt (LMU Munich), Florian Alt (LMU, Munich University of Applied Sciences)

We propose and evaluate a novel interaction technique to enhance physical keyboard shortcuts with arm and wrist rotation gestures, performed during keypresses: rolling the wrist, rotating the arm/wrist, and lifting it. This extends the set of shortcuts from key combinations (e.g. ctrl + v) to combinations of key(s) and gesture (e.g. v + roll left) and enables continuous control. We implement this approach for isolated single keypresses, using inertial sensors of a smartwatch. We investigate key aspects in three studies: 1) rotation flexibility per keystroke finger, 2) rotation control, and 3) user-defined gesture shortcuts. As a use case, we employ our technique in a painting application and assess user experience. Overall, results show that arm and wrist rotations during keystrokes can be used for interaction, yet challenges remain for integration into practical applications. We discuss recommendations for applications and ideas for future research.

Physical Keyboards in Virtual Reality: Analysis of Typing Performance and Effects of Avatar Hands

Pascal Knierim (LMU Munich), Valentin Schwind (University of Stuttgart), Anna Maria Feit (Aalto University Helsinki), Florian Nieuwenhuizen (University of Stuttgart), Niels Henze (University of Stuttgart)

Entering text is one of the most common tasks when interacting with computing systems. VR presents a challenge as neither the user's hands nor the physical input devices are directly visible. Hence, conventional desktop peripherals are very slow, imprecise, and cumbersome. We developed a apparatus that tracks the user's hands, and a physical keyboard, and visualize them in VR. In a text input study with 32 participants, we investigated the achievable text entry speed and the effect of hand representations and transparency on typing performance, workload, and presence. With our apparatus, experienced typists benefited from seeing their hands, and reach almost outside-VR performance. Inexperienced typists profited from semi-transparent hands, which enabled them to type just 5.6 WPM slower than with a regular desktop setup. We conclude that optimizing the visualization of hands in VR is important, especially for inexperienced typists, to enable a high typing performance.

Pocket Transfers: Interaction Techniques for Transferring Content from Situated Displays to Mobile Devices

Ville Mäkelä (University of Tampere), Mohamed Khamis (LMU Munich) Lukas Mecke (LMU Munich), Jobin James (University of Tampere), Markku Turunen (University of Tampere), Florian Alt (LMU Munich)

We present Pocket Transfers: interaction techniques that allow users to transfer content from situated displays to a personal mobile device while keeping the device in a pocket or bag. Existing content transfer solutions require direct manipulation of the mobile device, making inter-action slower and less flexible. Our introduced tech-niques employ touch, mid-air gestures, gaze, and a mul-timodal combination of gaze and mid-air gestures. We evaluated the techniques in a novel user study (N=20), where we considered dynamic scenarios where the user approaches the display, completes the task, and leaves. We show that all pocket transfer techniques are fast and seen as highly convenient. Mid-air gestures are the most efficient touchless method for transferring a single item, while the multimodal method is the fastest touchless method when multiple items are transferred. We provide guidelines to help researchers and practitioners choose the most suitable content transfer techniques for their systems.

Quadcopter-Projected In-Situ Navigation Cues for Improved Location Awareness

Pascal Knierim (LMU Munich), Steffen Maurer (Univ. Ulm), Katrin Wolf (HAW Hamburg), Markus Funk (TU Darmstadt)

Every day people rely on navigation systems when exploring unknown urban areas. Many navigation systems use multimodal feedback like visual, auditory or tactile cues. Although other systems exist, users mostly rely on a visual navigation using their smartphone. However, a problem with visual navigation systems is that the users have to shift their attention to the navigation system and then map the instructions to the real world. We suggest using in-situ navigation instructions that are presented directly in the environment by augmenting the reality using a projector-quadcopter. Through a user study with 16 participants, we show that using in-situ instructions for navigation leads to a significantly higher ability to observe real-world points of interest. Further, the participants enjoyed following the projected navigation cues.

ResearchIME: A Mobile Keyboard Application for Studying Free Typing Behaviour in the Wild

Daniel Buschek (LMU Munich), Benjamin Bisinger (LMU Munich), Florian Alt (LMU, Munich University of Applied Sciences)

We present a data logging concept, tool, and analyses to facilitate studies of everyday mobile touch keyboard use and free typing behaviour: 1) We propose a filtering concept to log typing without recording readable text and assess reactions to filters with a survey (N=349). 2) We release an Android keyboard app and backend that implement this concept. 3) Based on a three-week field study (N=30), we present the first analyses of keyboard use and typing biometrics on such free text typing data in the wild, including speed, postures, apps, auto correction, and word suggestions. We conclude that research on mobile keyboards benefits from observing free typing beyond the lab and discuss ideas for further studies.

Smart Kitchens for People with Cognitive Impairments: A Qualitative Study of Design Requirements

Thomas Kosch (LMU Munich), Pawel Wozniak (University of Stuttgart), Erin Brady (IUPUI, Indianapolis), Albrecht Schmidt (LMU Munich)

Individuals with cognitive impairments currently leverage extensive human resources during their transitions from assisted living to independent living. In Western Europe, many government-supported volunteer organizations provide sheltered living facilities; supervised environments in which people with cognitive impairments collaboratively learn daily living skills. In this paper, we describe communal cooking practices in sheltered living facilities and identify opportunities for supporting these with interactive technology to reduce volunteer workload. We conducted two contextual observations of twelve people with cognitive impairments cooking in sheltered living facilities and supplemented this data through interviews with four employees and volunteers who supervise them. Through thematic analysis, we identified four themes to inform design requirements for communal cooking activities: Work organization, community, supervision, and practicalities. Based on these, we present five design implications for assistive systems in kitchens for people with cognitive deficiencies.

Supporting Meaningful Personal Fitness: the Tracker Goal Evolution Model

Jasmin Niess (LMU Munich), Pawel Wozniak (University of Stuttgart)

While the number of users sporting fitness trackers is constantly increasing, little is understood about how tracking goals can evolve over time. As recent studies have shown that the long-term health effects of trackers are limited, we need to readdress how trackers engage users. We conducted semi-structured interviews and an online survey to explore how users change their tracking goals. Based on our results, we created the Tracker Goal Evolution Model. The model describes how tracker goals can evolve from internal user needs through qualitative goals to quantitative goals that can be used with trackers. It also includes trust and reflection as key contextual factors contributing to meaningful transitions between goals. We postulate showing how tracker goals relate to other personal fitness goals as key for long-term engagement with trackers. Our model is useful for designers of future trackers as a tool to create evolving and meaningful tracking goals.

Understanding Artefact and Process Challenges for Designing Low-Res Lighting Displays

Marius Hoggenmueller (LMU Munich), Martin Tomitsch (University of Sydney), Alexander Wiethoff (LMU Munich)

Low-resolution (low-res) lighting displays are increasingly used by HCI researchers, designers, and in the industry as a versatile and aesthetic medium for deploying ambient interfaces in various contexts. These display types distinguish themselves from conventional high-res screens through: high contrasts, hi-power LED technology which allows visibility even in bright environments, and their ability to take on three-dimensional free forms. However, to date most work on low-res displays has been either of experimental nature or carried out in isolated industry contexts. This paper addresses this gap through an analysis of our own experiences from previous experimental design studies and related work, which led us to five domain challenges for designing low-res displays. We then describe how we approached these challenges in a deployment study, which involved the implementation of a prototype guided by a low-res prototyping toolkit. Based on an analysis of our design process and findings from the deployment study, we present ten design recommendations for low-res lighting displays.

Understanding Face and Eye Visibility in Front-Facing Cameras of Smartphones used in the Wild

Mohamed Khamis (LMU Munich), Anita Baier (LMU Munich), Niels Henze (University of Stuttgart), Florian Alt (LMU Munich), Andreas Bulling (MPI Saarbrücken)

Commodity mobile devices are now equipped with high-resolution front-facing cameras, allowing applications in biometrics (e.g., FaceID in the iPhone X), facial expression analysis, or gaze interaction. However, it is unknown how often users hold devices in a way that allows capturing their face or eyes, and how this impacts detection accuracy. We collected 25,726 in-the-wild photos, taken from the front-facing camera of smartphones as well as associated application usage logs. We found that the full face is visible about 29% of the time, and that in most cases the face is only partially visible. Furthermore, we identified an influence of users' current activity; for example, when watching videos, the eyes but not the entire face are visible 75% of the time in our dataset. We found that a state-of-the-art face detection algorithm performs poorly against photos taken from front-facing cameras. We discuss how these findings impact mobile applications that leverage face and eye detection, and derive practical implications to address state-of-the art's limitations.

Which one is me? Identifying Oneself on Public Displays

Mohamed Khamis (LMU Munich), Christian Becker (LMU Munich), Andreas Bulling (MPI Saarbrücken), Florian Alt (LMU Munich)

While user representations are extensively used on public displays, it remains unclear how well users can recognize their own representation among those of surrounding users. We study the most widely used representations: abstract objects, skeletons, silhouettes and mirrors. In a prestudy (N=12), we identify five strategies that users follow to recognize themselves on public displays. In a second study (N=19), we quantify the users' recognition time and accuracy with respect to each representation type. Our findings suggest that there is a significant effect of (1) the representation type, (2) the strategies performed by users, and (3) the combination of both on recognition time and accuracy. We discuss the suitability of each representation for different settings and provide specific recommendations as to how user representations should be applied in multi-user scenarios. These recommendations guide practitioners and researchers in selecting the representation that optimizes the most for the deployment's requirements, and for the user strategies that are feasible in that environment.

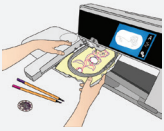
Your Eyes Tell: Leveraging Smooth Pursuit for Assessing Cognitive Workload

Thomas Kosch (LMU Munich), Mariam Hassib (LMU Munich), Pawel Wozniak (University of Stuttgart), Daniel Buschek (LMU Munich), Florian Alt (LMU Munich)

A common objective for context-aware computing systems is to predict how user interfaces impact user performance regarding their cognitive capabilities. Existing approaches such as questionnaires or pupil dilation measurements either only allow for subjective assessments or are susceptible to environmental influences and user physiology. We address these challenges by exploiting the fact that cognitive workload influences smooth pursuit eye movements. We compared three trajectories and two speeds under different levels of cognitive workload within a user study (N=20). We found higher deviations of gaze points during smooth pursuit eye movements for specific trajectory types at higher cognitive workload levels. Using an SVM classifier, we predict cognitive workload through smooth pursuit with an accuracy of 99.5% for distinguishing between low and high workload as well as an accuracy of 88.1% for estimating workload between three levels of difficulty. We discuss implications and present use cases of how cognition-aware systems benefit from inferring cognitive workload in real-time by smooth pursuit eye movements.

Sketch&Stitch: Interactive Embroidery for E-Textiles

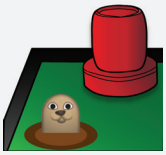
Nur Al-huda Hamdan (RWTH Aachen University), Simon Voelker (RWTH Aachen University), and Jan Borchers (RWTH Aachen University)



E-Textiles are fabrics that integrate electronic circuits and components. Makers use them to create interactive clothing, furniture, and toys. However, this requires significant manual labor and skills and using technology-centric design tools. We introduce Sketch&Stitch, an interactive embroidery system to create e-textiles using a traditional crafting approach: Users draw their art and circuit directly on fabric using colored pens. The system takes a picture of the sketch, converts it to embroidery patterns, and sends them to an embroidery machine. Alternating between sketching and stitching, users build and test their design incrementally. Sketch&Stitch features Circuitry Stickers representing circuit boards, components, and custom stitch patterns for wire crossings to insulate, and various textile touch sensors such as pushbuttons, sliders, and 2D touchpads. Circuitry Stickers serve as placeholders during design. Using computer vision, they are recognized and replaced later in the appropriate embroidery phases. We close with technical considerations and application examples.

Tangible Awareness: How Tangibles on Tabletops Influence Awareness of Each Other's Actions

Christian Cherek (RWTH Aachen University), Anke Brocker (RWTH Aachen University), Simon Voelker (RWTH Aachen University), and Jan Borchers (RWTH Aachen University)



Tangibles on multitouch tabletops increase speed, accuracy, and eyes-free operability for individual users, and verbal and behavioral social interaction among multiple users around smaller tables with a shared focus of attention. Modern multitouch tables, however, provide sizes and resolutions that let groups work alongside each other in separate workspaces. But how aware do these users remain of each other's actions, and what impact can tangibles have on their awareness? In our study, groups of 2–4 users around the table played an individual game grabbing their attention as primary task, while they also had to occasionally become aware of other players' actions and react as a secondary task. We found that players were significantly more aware of other players' actions using tangibles than those using pure multitouch interaction, indicated by faster reaction times. This effect was especially strong with more players. We close with qualitative user feedback and design recommendations.

Use the Force Picker, Luke: Space-Efficient Value Input on Force-Sensitive Mobile Touchscreens

Christian Corsten (RWTH Aachen University), Simon Voelker (RWTH Aachen University), Andreas Link (RWTH Aachen University), and Jan Borchers (RWTH Aachen University)

Picking values from long ordered lists, such as when setting a date or time, is a common task on smartphones. However, the system pickers and tables used for this require significant screen space for spinning and dragging, covering other information or pushing it off-screen. The Force Picker reduces this footprint by letting users increase and decrease values over a wide range using force touch for rate-based control. However, changing input direction this way is difficult. We propose three techniques to address this. With our best candidate, Thumb-Roll, the Force Picker lets untrained users achieve similar accuracy as a standard picker, albeit less quickly. Shrinking it to a single table row, 20% of the iOS picker height, slightly affects completion time, but not accuracy. Intriguingly, after 70 minutes of training, users were significantly faster with this minimized Thumb-Roll Picker compared to the standard picker, with the same accuracy and only 6% of the gesture footprint. We close with application examples.

Grand Challenges in Shape-Changing Interface Research

Jason Alexander (Lancaster University), Anne Roudaut (University of Bristol), Jürgen Steimle (Uni Saarland), Kasper Hornbæk (University of Copenhagen), Miguel Bruns Alonso (TU Eindhoven), Sean Follmer (Stanford University), Timothy Merritt (Aalborg University)

Shape-changing interfaces have emerged as a new method for interacting with computers, using dynamic changes in a device's physical shape for input and output. With the advances of research into shape-changing interfaces, we see a need to synthesize the main, open research questions. The purpose of this synthesis is to formulate common challenges across the diverse fields engaged in shape-change research, to facilitate progression from single prototypes and individual design explorations to grander scientific goals, and to draw attention to challenges that come with maturity, including those concerning ethics, theory-building, and societal impact. In this article we therefore present 12 grand challenges for research on shape-changing interfaces, derived from a threeday workshop with 25 shape-changing interface experts with backgrounds in design, computer science, human-computer interaction, engineering, robotics, and material science.

Modeling Perceived Screen Resolution Based on Position and Orientation of Wrist-Worn Devices

Frederic Kerber (DFKI / Uni Saarland), Michael Mauderer (University of Dundee), Antonio Krüger (DFKI / Uni Saarland)

This paper presents a model allowing inferences of perceivable screen content in relation to position and orientation of mobile or wearable devices with respect to their user. The model is based on findings from vision science and allows prediction of a value of effective resolution that can be perceived by a user. It considers distance and angle between the device and the eyes of the observer as well as the resulting retinal eccentricity when the device is not directly focused but observed in the periphery. To validate our model, we conducted a study with 12 participants. Based on our results, we outline implications for the design of mobile applications that are able to adapt themselves to facilitate information throughput and usability.

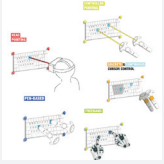
Multi-Touch Skin: A Thin and Flexible Multi-Touch Sensor for On-Skin Input

Aditya Shekhar Nittala (Uni Saarland), Anusha Withana (Uni Saarland), Narjes Pourjafarian (Uni Saarland), Jürgen Steimle (Uni Saarland)

Skin-based touch input opens up new opportunities for direct, subtle, and expressive interaction. However, existing skin-worn sensors are restricted to single-touch input and limited by a low resolution. We present the first skin overlay that can capture high-resolution multi-touch input. Our main contributions are: 1) Based on an exploration of functional materials, we present a fabrication approach for printing thin and flexible multi-touch sensors for on-skin interactions. 2) We present the first non-rectangular multi-touch sensor overlay for use on skin and introduce a design tool that generates such sensors in custom shapes and sizes. 3) To validate the feasibility and versatility of our approach, we present four application examples and empirical results from two technical evaluations. They confirm that the sensor achieves a high signal-to-noise ratio on the body under various grounding conditions and has a high spatial accuracy even when subjected to strong deformations.

Selection-based Text Entry in Virtual Reality

Marco Speicher (DFKI / Uni Saarland), Anna Maria Feit (Aalto University), Pascal Ziegler (DFKI / Uni Saarland), Antonio Krüger (DFKI / Uni Saarland)



In recent years, Virtual Reality (VR) and 3D User Interfaces (3DUI) have seen a drastic increase in popularity, especially in terms of consumer-ready hardware and software. While the technology for input as well as output devices is market ready, only a few solutions for text input exist, and empirical knowledge about performance and user preferences is lacking. In this paper, we study text entry in VR by selecting characters on a virtual keyboard. We discuss the design space for assessing selection-based text entry in VR. Then, we implement six methods that span different parts of the design space and evaluate their performance and user preferences. Our results show that pointing using tracked hand-held controllers outperforms all other methods. Other methods such as head pointing can be viable alternatives depending on available resources. We summarize our findings by formulating guidelines for choosing optimal virtual keyboard text entry methods in VR.

Off-Line Sensing: Memorizing Interactions in Passive 3D-Printed Objects

Martin Schmitz (TU Darmstadt), Martin Herbers, Niloofar Dezfuli, Sebastian Günther, Max Mühlhäuser

Embedding sensors into objects allow them to recognize various interactions.However, sensing usually requires active electronics that are often costly, need time to be assembled, and constantly draw power. Thus, we propose off-line sensing: passive 3D-printed sensors that detect one-time interactions, such as accelerating or flipping, but neither require active electronics nor power at the time of the interaction. They memorize a pre-defined interaction via an embedded structure filled with a conductive medium (e.g., a liquid). Whether a sensor was exposed to the interaction can be read-out via a capacitive touchscreen. Sensors are printed in a single pass on a consumer-level 3D printer. Through a series of experiments, we show the feasibility of off-line sensing.

What Did I Really Vote For? On the Usability of Verifiable E-Voting Schemes

Karola Marky (TU Darmstadt), Oksana Kulyk (TU Darmstadt), Karen Renaud (Abertay University, University of South Africa), Melanie Volkamer (Karlsruhe Institute of Technology, TU Darmstadt)

E-voting has been embraced by a number of countries, delivering benefits in terms of efficiency and accessibility. End-to-end verifiable e-voting schemes facilitate verification of the integrity of individual votes during the election process. In particular, methods for cast-as-intended verification enable voters to confirm that their cast votes have not been manipulated by the voting client. A well-known technique for effecting cast-as-intended verification is the Benaloh Challenge. The usability of this challenge is crucial because voters have to be actively engaged in the verification process. In this paper, we report on a usability evaluation of three different approaches of the Benaloh Challenge in the remote e-voting context.We performed a comparative user study with 95 participants. We conclude with a recommendation for which approaches should be provided to afford verification in real-world elections and suggest usability improvements.

Comparing Computer-Based Drawing Methods for Blind People with Real-Time Tactile Feedback

Jens Bornschein (Technische Universität Dresden), Denise Bornschein (Technische Universität Dresden), Gerhard Weber (Technische Universität Dresden)

In this paper, we present a drawing workstation for blind people using a two-dimensional tactile pin-matrix display for in- and output. Four different input modalities, namely menu-based, gesture-based, freehand-stylus and a Time-of-Flight (ToF) depth segmentation of real-world object silhouettes, are utilized to create graphical shapes. Users can freely manipulate shapes after creation. Twelve blind users evaluated and compared the four image creation modalities. During evaluation, participants had to copy four different images. The results show that all modalities are highly appropriate for non-visual drawing tasks. There is no generally preferred drawing modality, but most participants rated the robust and well-known menu-based interaction as very good. Furthermore, menu was second in performance and the most accurate drawing modality. Our evaluation demonstrated direct manipulation works well for blind users at the position of the reading hand. In general, our drawing tool allows blind users to create appealing images.

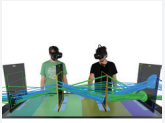
When David Meets Goliath: Combining Smartwatches with a Large Vertical Display for Visual Data Exploration

Tom Horak (Interactive Media Lab, Technische Universität Dresden), Sriram Karthik Badam (University of Maryland), Niklas Elmqvist (University of Maryland), Raimund Dachselt (Interactive Media Lab, Technische Universität Dresden)

We explore the combination of smartwatches and a large interactive display to support visual data analysis. These two extremes of interactive surfaces are increasingly popular, but feature different characteristics—display and input modalities, personal/public use, performance, and portability. In this paper, we first identify possible roles for both devices and the interplay between them through an example scenario. We then propose a conceptual framework to enable analysts to explore data items, track interaction histories, and alter visualization configurations through mechanisms using both devices in combination. We validate an implementation of our framework through a formative evaluation and a user study. The results show that this device combination, compared to just a large display, allows users to develop complex insights more fluidly by leveraging the roles of the two devices. Finally, we report on the interaction patterns and interplay between the devices for visual exploration as observed during our study.

Clusters, Trends, and Outliers: How Immersive Technologies Can Facilitate the Collaborative Analysis of Multidimensional Data

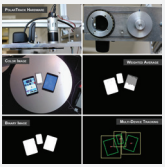
Simon Butscher (University of Konstanz), Sebastian Hubenschmid (University of Konstanz), Jens Müller (University of Konstanz), Johannes Fuchs (University of Konstanz), Harald Reiterer (University of Konstanz)



Immersive technologies such as augmented reality devices are opening up a new design space for the visual analysis of data. This paper studies the potential of an augmented reality environment for the purpose of collaborative analysis of multidimensional, abstract data. We present ART, a collaborative analysis tool to visualize multidimensional data in augmented reality using an interactive, 3D parallel coordinates visualization. The visualization is anchored to a touch-sensitive tabletop, benefiting from well-established interaction techniques. The results of group-based expert walkthroughs show that ART can facilitate immersion in the data, a fluid analysis process, and collaboration. Based on the results, we provide a set of guidelines and discuss future research areas to foster the development of immersive technologies as tools for the collaborative analysis of multidimensional data.

PolarTrack: Optical Outside-In Device Tracking that Exploits Display Polarization

Roman Rädle (Aarhus University), Hans-Christian Jetter (University of Applied Sciences Upper Austria), Jonathan Fischer (University of Konstanz), Inti Gabriel (University of Konstanz), Clemens N. Klokmose (Aarhus University), Harald Reiterer (University of Konstanz), Christian Holz (Microsoft Research)



PolarTrack is a novel camera-based approach to detecting and tracking mobile devices inside the capture volume. In PolarTrack, a polarization filter continuously rotates in front of an off-the-shelf color camera, which causes the displays of observed devices to periodically blink in the camera feed. The periodic blinking results from the physical characteristics of current displays, which shine polarized light either through an LC overlay to produce images or through a polarizer to reduce light reflections on OLED displays. PolarTrack runs a simple detection algorithm on the camera feed to segment displays and track their locations and orientations, which makes PolarTrack particularly suitable as a tracking system for cross-device interaction with mobile devices. Our evaluation of PolarTrack's tracking quality and comparison with state-of-the-art camera-based multi-device tracking showed a better tracking accuracy and precision with similar tracking reliability. PolarTrack works as standalone multi-device tracking but is also compatible with existing camera-based tracking systems and can complement them to compensate for their limitations.

All about Acceptability?: Identifying Factors for the Adoption of Data Glasses

Marion Koelle (Uni Oldenburg), Abdallah El Ali (Uni Oldenburg), Vanessa Cobus (OFFIS), Wilko Heuten (OFFIS), Susanne Boll (Uni Oldenburg)

Innovations often trigger objections before becoming widely accepted. This paper assesses whether a familiarisation over time can be expected for data glasses, too. While user attitudes towards those devices have been reported to be prevalently negative [14], it is still unclear, to what extent this initial, negative user attitude might impede adoption. However, indepth understanding is crucial for reducing barriers early in order to gain access to potential benefits from the technology. With this paper we contribute to a better understanding of factors affecting data glasses adoption, as well as current trends and opinions. Our multiple-year case study (N=118) shows, against expectations, no significant change towards a more positive attitude between 2014 and 2016. We complement these findings with an expert survey (N=51) investigating prognoses, challenges and discussing the relevance of social acceptability. We elicit and contrast a controversial spectrum of expert opinions, and assess whether initial objections can be overwritten. Our analysis shows that while social acceptability is considered relevant for the time being, utility and usability are more valued for long-term adoption.

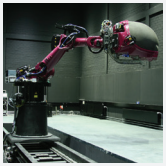
Exploring Social Awareness: A Design Case Study in Minimal Communication

Torben Wallbaum (OFFIS), Maria Rauschenberger (Universitat Pompeu Fabra Barcelona), Janko Timmermann (BTC Embedded Systems AG), Wilko Heuten (OFFIS), Susanne Boll (Uni Oldenburg)

Computer-mediated communication technology is ubiquitous in today's society. However, the design of these technologies often takes a screen-based approach and requires users to adopt new usage conventions. While these methods have been widely successful in helping individuals communicate, we take a step back in this paper and explore the design implications of a simpler tangible system for keeping in touch. This system consists of a pair of artificial electronic flowers, which connect and transmit information to each other. Our contribution is not in the actual implementation, but rather in the design implications that follow. In our modest evaluation we found participants using our system in informal, relaxed and sometimes novel ways.

Feel the Movement: Real Motion Influences Responses to Take-over Requests in Highly Automated Vehicles

Shadan Sadeghian Borojeni (OFFIS), Susanne Boll (Uni Oldenburg), Wilko Heuten (OFFIS), Heinrich H. Bülthoff (Max Planck Institute for Biological Cybernetics, Tübingen) Lewis Chuang (Max Planck Institute for Biological Cybernetics, Tübingen)



Take-over requests (TORs) in highly automated vehicles arecues that prompt users to resume control. TORs however,are often evaluated in non-moving driving simulators. Thisignores the role of motion, an important source of informationfor users who have their eyes off the road while engaged innon-driving related tasks. We ran a user study in a moving-base driving simulator to investigate the effect of motion onTOR responses. We found that with motion, user responsesto TORs vary depending on the road context where TORs areissued. While previous work showed that participants are fastto respond to urgent cues, we show that this is true only whenTORs are presented on straight roads. Urgent cues issued oncurved roads elicit slower responses than non-urgent cueson curved roads. Our findings indicate that TORs should bedesigned to be aware of road context to accommodate naturaluser responses.

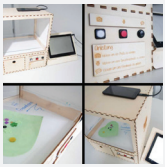
Measuring, Understanding, and Classifying News Media Sympathy on Twitter after Crisis Events

Abdallah El Ali (Centrum Wiskunde & Informatica, The Netherlands / Uni Oldenurg) Tim C Stratmann (Uni Oldenburg), Souneil Park (Telefonica Research), Johannes Schöning (Uni Bremen), Wilko Heuten (OFFIS), Susanne Boll (Uni Oldenburg)

This paper investigates bias in coverage between Western and Arab media on Twitter after the November 2015 Beirut and Paris terror attacks. Using two Twitter datasets covering each attack, we investigate how Western and Arab media differed in coverage bias, sympathy bias, and resulting information propagation. We crowdsourced sympathy and sentiment labels for 2,390 tweets across four languages (English, Arabic, French, German), built a regression model to characterize sympathy, and thereafter trained a deep convolutional neural network to predict sympathy. Key findings show: (a) both events were disproportionately covered (b) Western media exhibited less sympathy, where each media coverage was more sympathetic towards the country affected in their respective region (c) Sympathy predictions supported ground truth analysis that Western media was less sympathetic than Arab media (d) Sympathetic tweets do not spread any further. We discuss our results in light of global news flow, Twitter affordances, and public perception impact.

Supporting Communication between Grandparents and Grandchildren through Tangible Storytelling Systems

Torben Wallbaum (OFFIS), Andrii Matviienko (OFFIS), Swamy Ananthanarayan (Uni Oldenburg), Thomas Olsson (University of Tampere), Wilko Heuten (OFFIS), Susanne Boll (Uni Oldenburg)



Grandparents and grandchildren that live apart often rely on communication technologies, such as messengers, video conferencing, and phone calls for maintaining relationships. While some of these systems are challenging for grandparents, others are less engaging for children. To facilitate communication, we developed StoryBox, a tangible device that allows sharing photos, tangible artifacts, and audio recordings of everyday life. We conducted a preliminary study with two families to identify design issues, and further refine the prototype. Subsequently, we conducted a field study with four families for up to four weeks to better understand real-world use and examine inter-generational connectedness. We found that StoryBox was accessible, simple, and helped bridge the technological gap between grandparents and grandchildren. Children communicated asynchronously in a playful and idiosyncratic manner, and grandparents shared past family memories. We provide insights on how to ease communication between different generations, engage them in sharing activities, and strengthen family relationships.

Exploring the Potential of Exergames to affect the Social and Daily Life of People with Dementia and their Caregivers

David Unbehaun (University of Siegen), Daryoush Vaziri (University of Applied Sciences St. Augustin), Konstantin Aal (University of Siegen), Rainer Wieching (University of Siegen), Peter Tolmie (University of Siegen), Volker Wulf (University of Siegen)

This paper presents the outcomes of an exploratory field study that examined the social impact of an ICT-based suite of exergames for people with dementia and their caregivers. Qualitative data was collected over a period of 8 months, during which time we studied the daily life of 14 people with dementia and their informal and professional caregivers. We focus on the experiential aspects of the system and examine its social impact when integrated into the daily routines of both people with dementia themselves and their professional and family caregivers. Our findings indicate that relatives were able to regain leisure time, whilst people with dementia were able to recapture certain aspects of their social and daily activities that might otherwise have been lost to them. Results suggest that the system enhanced social-interaction, invigorated relationships, and improved the empowerment of people with dementia and their caregivers to face daily challenges.

Microblog Analysis as a Program of Work

Peter Tolmie (Universität Siegen), Rob Procter (University of Warwick), Mark Rouncefield (Lancaster University), Maria Liakata (University of Warwick), Arkaitz Zubiaga (University of Warwick)

Inspired by a European project, PHEME, that requires the close analysis of Twitter-based conversations in order to look at the spread of rumors via social media, this article has two objectives. The first of these is to take the analysis of microblogs back to first principles and lay out what microblog analysis should look like as a foundational program of work. The other is to describe how this is of fundamental relevance to human-computer interaction's interest in grasping the constitution of people's interactions with technology within the social order. Our critical finding is that, despite some surface similarities, Twitter-based conversations are a wholly distinct social phenomenon requiring an independent analysis that treats them as unique phenomena in their own right, rather than as another species of conversation that can be handled within the framework of existing conversation analysis. This motivates the argument that microblog analysis be established as a foundationally independent program, examining the organizational characteristics of microblogging from the ground up. We articulate how aspects of this approach have already begun to shape our design activities within the PHEME project.

The Use of Private Mobile Phones at War: Accounts From the Donbas Conflict

Irina Shklovski (IT University of Copenhagen), Volker Wulf (University of Siegen)

Studying technology use in unstable and life-threatening conditions can help highlight assumptions of use built into technologies and foreground contradictions in the design of devices and services. This paper provides an account of how soldiers, volunteers, and civilians use mobile technologies in wartime, reporting on fieldwork conducted in Western Russia and Eastern Ukraine with people close to or participating directly in the armed conflict in the Donbas region. We document how private mobile phones and computers became a crucial but ambiguous infrastructure despite their lack of durability in extreme conditions of a military conflict, and their government and military surveillance potential. Our participants rely on a combination of myths and significant technical knowledge to negotiate the possibilities mobile technologies offer and the lifethreatening reality of enemy surveillance they engender. We consider the problems of always-on always-connected devices under conditions of war and surveillance and our responsibilities as HCI practitioners in the design of social technologies.

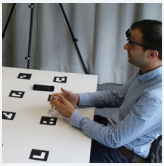
Designing Consistent Gestures Across Device Types: Eliciting RSVP Controls for Phone, Watch, and Glasses

Tilman Dingler (Osaka Prefecture University), Rufat Rzayev (University of Stuttgart), Alireza Sahami Shirazi (University of Stuttgart), Niels Henze (University of Stuttgart)

In the era of ubiquitous computing, people expect applications to work across different devices. To provide a seamless user experience it is therefore crucial that interfaces and interactions are consistent across different device types. In this paper, we present a method to create gesture sets that are consistent and easily transferable. Our proposed method entails 1) the gesture elicitation on each device type, 2) the consolidation of a unified gesture set, and 3) a final validation by calculating a transferability score. We tested our approach by eliciting a set of user-defined gestures for reading with Rapid Serial Visual Presentation (RSVP) of text for three device types: phone, watch, and glasses. We present the resulting, unified gesture set for RSVP reading and show the feasibility of our method to elicit gesture sets that are consistent across device types with different form factors.

Evaluating the Disruptiveness of Mobile Interactions: A Mixed-Method Approach

Sven Mayer (University of Stuttgart), Lars Lischke (University of Stuttgart), Paweł W. Woźniak (University of Stuttgart), Niels Henze (University of Stuttgart)



While the proliferation of mobile devices has rendered mobile notifications ubiquitous, researchers are only slowly beginning to understand how these technologies affect everyday social interactions. In particular, the negative social influence of mobile interruptions remains unexplored from a methodological perspective. This paper contributes a mixed-method evaluation procedure for assessing the disruptive impact of mobile interruptions in conversation. The approach combines quantitative eye tracking, qualitative analysis, and a simulated conversation environment to enable fast assessment of disruptiveness. It is intended to be used as a part of an iterative interaction design process. We describe our approach in detail, present an example of its use to study a new call declining technique, and reflect upon the pros and cons of our approach.

Fingers' Range and Comfortable Area for One-Handed Smartphone Interaction Beyond the Touchscreen

Huy Viet Le (University of Stuttgart), Sven Mayer (University of Stuttgart), Patrick Bader (University of Stuttgart), Niels Henze (University of Stuttgart)

Previous research and recent smartphone development presented a wide range of input controls beyond the touchscreen. Fingerprint scanners, silent switches, and Back-of-Device (BoD) touch panels offer additional ways to perform input. However, with the increasing amount of input controls on the device, unintentional input or limited reachability can hinder interaction. In a one-handed scenario, we conducted a study to investigate the areas that can be reached without losing grip stability (comfortable area), and with stretched fingers (maximum range) using four different phone sizes. We describe the characteristics of the comfortable area and maximum range for different phone sizes and derive four design implications for the placement of input controls to support one-handed BoD and edge interaction. Amongst others, we show that the index and middle finger are the most suited fingers for BoD interaction and that the grip shifts towards the top edge with increasing phone sizes.

KnobSlider: Bottom-Up Design of a Shape-Changing UI for Parameters Control

Hyunyoung Kim (Université Grenoble Alpes, CNRS, LIG & University of Stuttgart), Celine Coutrix (Université Grenoble Alpes, CNRS, LIG & University of Stuttgart), Anne Roudaut (University of Bristol)

Physical controls are widely used by professionals such as sound engineers or aircraft pilots. In particular knobs and sliders are the most prevalent in such interfaces. They have advantages over touchscreen GUIs, especially when users require quick and eyes-free control. However, their interfaces (e.g., mixing consoles) are often bulky and crowded. To improve this, we present the results of a formative study with professionals who use physical controllers. Based on their feedback, we propose design requirements for future interfaces for parameters control. We then introduce the design of our KnobSlider that combines the advantages of a knob and a slider in one unique shape-changing device. A qualitative study with professionals shows how KnobSlider supports the design requirements, and inspired new interactions and applications.

Morphees+: Studying Everyday Reconfigurable Objects for the Design and Taxonomy of Reconfigurable UIs

Hyunyoung Kim (Université Grenoble Alpes, CNRS, LIG & University of Stuttgart), Celine Coutrix (Université Grenoble Alpes, CNRS, LIG & University of Stuttgart), Anne Roudaut (University of Bristol)

Users interact with many reconfigurable objects in daily life. These objects embed reconfigurations and shape-changing features that users are familiar with. For this reason, everyday reconfigurable objects have informed the design and taxonomy of shape changing UI. However, they have never been explored systematically. In this paper, we present a data set of 82 everyday reconfigurable objects that we collected in a workshop. We discuss how they can inspire the design of reconfigurable interfaces. We particularly focus on taxonomies of reconfigurable interfaces. Taxonomies have been suggested to help design and communication among researchers, however despite their extensive use, taxonomies are rarely evaluated. This paper analyses two established taxonomies - Rasmussen's and Roudaut's - using daily reconfigurable objects. We show relationships between the taxonomies and area for improvements. We propose Morphees+, a refined taxonomy based on Roudaut's Shape Resolution Taxonomy.

Navigation Systems for Motorcyclists: Exploring Wearable Tactile Feedback for Route Guidance in the Real World

Francisco Kiss (University of Stuttgart), Robin Boldt (University of Stuttgart), Bastian Pfleging (LMU Munich), Stefan Schneegass (University of Duisburg-Essen)

Current navigation systems for motor cyclists use visual or auditory cues for guidance. However, this poses a challenge to the motorcyclists since their visual and auditory channels are already occupied with controlling the motorbike, paying attention to other road users, and planing the next turn. In this work, we explore how tactile feedback can be used to guide motorcyclists. We present MOVING (MOtorbike VIbrational Navigation Guidance), a smart kidney belt that presents navigation cues through 12 vibration motors. In addition, we report on the design process of this wearable and on an evaluation with 16 participants in a real world riding setting. We show that MOVING outperforms off-the-shelf navigation systems in terms of turn errors and distraction.

Pac-Many: Movement Behavior when Playing Collaborative and Competitive Games on Large Displays

Sven Mayer (University of Stuttgart), Lars Lischke (University of Stuttgart), Jens Emil Grønbæk (Aarhus University), Zhanna Sarsenbayeva (The University of Melbourne), Jonas Vogelsang (University of Stuttgart), Paweł W. Woźniak (University of Stuttgart), Niels Henze (University of Stuttgart), Giulio Jacucci (University of Helsinki)

Previous work has shown that large high resolution displays (LHRDs) can enhance collaboration between users. As LHRDs allow free movement in front of the screen, an understanding of movement behavior is required to build successful interfaces for these devices. This paper presents Pac-Many; a multiplayer version of the classical computer game Pac-Man to study group dynamics when using LHRDs. We utilized smartphones as game controllers to enable free movement while playing the game. In a lab study, using a 4m × 1m LHRD, 24 participants (12 pairs) played Pac-Many in collaborative and competitive conditions. The results show that players in the collaborative condition divided screen space evenly. In contrast, competing players stood closer together to avoid benefits for the other player. We discuss how the nature of the task is important when designing and analyzing collaborative interfaces for LHRDs. Our work shows how to account for the spatial aspects of interaction with LHRDs to build immersive experiences.

PalmTouch: Using the Palm as an Additional Input Modality on Commodity Smartphones

Huy Viet Le (University of Stuttgart), Thomas Kosch (LMU Munich), Patrick Bader (University of Stuttgart), Sven Mayer (University of Stuttgart), Sven, Niels Henze (University of Stuttgart)

Touchscreens are the most successful input method for smartphones. Despite their flexibility, touch input is limited to the location of taps and gestures. We present PalmTouch, an additional input modality that differentiates between touches of fingers and the palm. Touching the display with the palm can be a natural gesture since moving the thumb towards the device's top edge implicitly places the palm on the touchscreen. We present different use cases for PalmTouch, including the use as a shortcut and for improving reachability. To evaluate these use cases, we have developed a model that differentiates between finger and palm touch with an accuracy of 99.53% in realistic scenarios. Results of the evaluation show that participants perceive the input modality as intuitive and natural to perform. Moreover, they appreciate PalmTouch as an easy and fast solution to address the reachability issue during onehanded smartphone interaction compared to thumb stretching or grip changes.

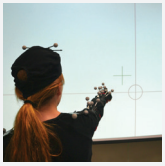
Reading on Smart Glasses: The Effect of Text Position, Presentation Type and Walking

Rufat Rzayev (University of Stuttgart), Paweł W. Woźniak (University of Stuttgart), Tilman Dingler (Osaka Prefecture University), Niels Henze (University of Stuttgart)

Smart glasses are increasingly being used in professional contexts. Having key applications such as short messaging and newsreader, they enable continuous access to textual information. In particular, smart glasses allow reading while performing other activities as they do not occlude the user's world view. For efficient reading, it is necessary to understand how a text should be presented on them. We, therefore, conducted a study with 24 participants using a Microsoft HoloLens to investigate how to display text on smart glasses while walking and sitting. We compared text presentation in the top-right, center, and bottom-center positions with Rapid Serial Visual Presentation (RSVP) and line-by-line scrolling. We found that text displayed in the top-right of smart glasses increases subjective workload and reduces comprehension. RSVP yields higher comprehension while sitting. Conversely, reading with scrolling yields higher comprehension while walking. Insights from our study inform the design of reading interfaces for smart glasses.

The Effect of Offset Correction and Cursor on Mid-Air Pointing in Real and Virtual Environments

Sven Mayer (University of Stuttgart), Valentin Schwind (University of Stuttgart), Robin Schweigert (University of Stuttgart), Niels Henze (University of Stuttgart)



Pointing at remote objects to direct others' attention is a fundamental human ability. Previous work explored methods for remote pointing to select targets. Absolute pointing techniques that cast a ray from the user to a target are affected by humans' limited pointing accuracy. Recent work suggests that accuracy can be improved by compensating systematic offsets between targets a user aims at and rays cast from the user to the target. In this paper, we investigate mid-air pointing in the real world and virtual reality. Through a pointing study, we model the offsets to improve pointing accuracy and show that being in a virtual environment affects how users point at targets. In the second study, we validate the developed model and analyze the effect of compensating systematic offsets. We show that the provided model can significantly improve pointing accuracy when no cursor is provided. We further show that a cursor improves pointing accuracy but also increases the selection time

What to Put on the User: Sensing Technologies for Studies and Physiology Aware Systems

Hänsel Katrin (Queen Mary University of London), Romina Poguntke (University of Stuttgart), Hamed Haddadi (Imperial College), Akram Alomainy (Queen Mary University of London), Albrecht Schmidt (LMU Munich)

Fitness trackers not just provide easy means to acquire physiological data in real-world environments due to affordable sensing technologies, they further offer opportunities for physiology-aware applications and studies in HCI; however, their performance is not well understood. In this paper, we report findings on the quality of 3 sensing technologies: PPG-based wrist trackers (Apple Watch, Microsoft Band 2), an ECG-belt (Polar H7) and reference device with stick-on ECG electrodes (Nexus 10). We collected physiological (heart rate, electrodermal activity, skin temperature) and subjective data from 21 participants performing combinations of physical activity and stressful tasks. Our empirical research indicates that wrist devices provide a good sensing performance in stationary settings. However, they lack accuracy when participants are mobile or if tasks require physical activity. Based on our findings, we suggest a Design Space for Wearables in Research Settings and reflected on the appropriateness of the investigated technologies in research contexts.

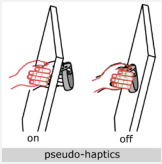
Breaking the Tracking: Enabling Weight Perception using Perceivable Tracking Offsets

Michael Rietzler (Ulm University), Florian Geiselhart (Ulm University), Jan Gugenheimer (Ulm University), Enrico Rukzio (Ulm University)

Virtual reality (VR) technology strives to enable a highly immersive experience for the user by including a wide variety of modalities (e.g. visuals, haptics). Current VR hardware however lacks a sufficient way of communicating the perception of weight of an object, resulting in scenarios where users can not distinguish between lifting a bowling ball or a feather. We propose a solely software based approach of simulating weight in VR by deliberately using perceivable tracking offsets. These tracking offsets nudge users to lift their arm higher and result in a visual and haptic perception of weight. We conducted two user studies showing that participants intuitively associated them with the sensation of weight and accept them as part of the virtual world. We further show that compared to no weight simulation, our approach led to significantly higher levels of presence, immersion and enjoyment. Finally, we report perceptional thresholds and offset boundaries as design guidelines for practitioners.

Conveying the Perception of Kinesthetic Feedback in Virtual Reality using State-of-the-Art Hardware

Michael Rietzler (Ulm University), Florian Geiselhart (Ulm University), Julian Frommel (Ulm University), Enrico Rukzio (Ulm University)



Including haptic feedback in current consumer VR applications is frequently challenging, since technical possibilities to create haptic feedback in consumer-grade VR are limited. While most systems include and make use of the possibility to create tactile feedback through vibration, kinesthetic feedback systems almost exclusively rely on external mechanical hardware to induce actual sensations so far. In this paper, we describe an approach to create a feeling of such sensations by using unmodified off-the-shelf hardware and a software solution for a multi-modal pseudo-haptics approach. We first explore this design space by applying user-elicited methods, and afterwards evaluate our refined solution in a user study. The results show that it is indeed possible to communicate kinesthetic feedback by visual and tactile cues only and even induce its perception. While visual clipping was generally unappreciated, our approach led to significant increases of enjoyment and presence.

FaceDisplay: Towards Asymmetric Multi-User Interaction for Nomadic Virtual Reality

Jan Gugenheimer (Ulm University), Evgeny Stemasov (Ulm University), Harpreet Sareen (MIT Media Lab), Enrico Rukzio (Ulm University)

Mobile VR HMDs enable scenarios where they are being used in public, excluding all the people in the surrounding (Non-HMD Users) and reducing them to be sole bystanders. We present FaceDisplay, a modified VR HMD consisting of three touch sensitive displays and a depth camera attached to its back. People in the surrounding can perceive the virtual world through the displays and interact with the HMD user via touch or gestures. To further explore the design space of FaceDisplay, we implemented three applications (FruitSlicer, SpaceFace and Conductor) each presenting different sets of aspects of the asymmetric co-located interaction (e.g. gestures vs touch). We conducted an exploratory user study (n=16), observing pairs of people experiencing two of the applications and showing a high level of enjoyment and social interaction with and without an HMD. Based on the findings we derive design considerations for asymmetric co-located VR applications

KickAR: Exploring Game Balancing Through Boosts and Handicaps in Augmented Reality Table Football

Katja Rogers (Ulm University), Mark Colley (Ulm University), David Lehr (Ulm University), Julian Frommel (Ulm University), Marcel Walch (Ulm University), Lennart E. Nacke (University of Waterloo), Michael Weber (Ulm University)

When player skill levels are not matched, games provide an unsatisfying player experience. Player balancing is used across many digital game genres to address this, but has not been studied for co-located augmented reality (AR) tabletop games, where using boosts and handicaps can adjust for different player skill levels. In the setting of an AR table football game, we studied the importance of game balancing being triggered by the game system or the players, and whether player skill should be required to trigger game balancing. We implemented projected icons to prominently display game balancing mechanics in the AR table football game. In a within-subjects study (N=24), we found players prefer skill-based control over game balancing and that different triggers are perceived as having different fairness. Further, the study showed that even game balancing that is perceived as unfair can provide enjoyable game experiences. Based on our findings, we provide suggestions for player balancing in AR tabletop games.

Vanishing Importance: Studying Immersive Effects of Game Audio Perception on Player Experiences in Virtual Reality

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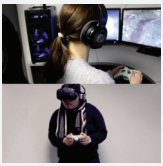

Sound and virtual reality (VR) are two important output modalities for creating an immersive player experience (PX). While prior research suggests that sounds might contribute to a more immersive experience in games played on screens and mobile displays, there is not yet evidence of these effects of sound on PX in VR. To address this, we conducted a within-subjects experiment using a commercial horror-adventure game to study the effects of a VR and monitor-display version of the same game on PX. Subsequently, we explored, in a between-subjects study, the effects of audio dimensionality on PX in VR. Results indicate that audio has a more implicit influence on PX in VR because of the impact of the overall sensory experience and that audio dimensionality in VR may not be a significant factor contributing to PX. Based on our findings and observations, we provide five design guidelines for VR games.

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