Report from Dagstuhl Seminar 12151

Touching the 3rd Dimension

Edited by

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Abstract

In recent years interactive visualization of 3D data has become important and widespread due to the requirements of several application areas. However, current user interfaces often lack adequate support for 3D interactions: 2D desktop systems are often limited in cases where natural interaction with 3D content is required, and 3D user interfaces consisting of stereoscopic projections and tracked input devices are rarely adopted by ordinary users. Touch interaction has received considerable attention for 2D interfaces, and more recently for 3D interfaces. Many touch devices now support multiple degrees of freedom input by capturing multiple 2D contact positions on the surface as well as varying levels of pressure and even depth. There is great potential for multi-touch interfaces to provide the traditionally difficult to achieve combination of natural 3D interaction without any instrumentation. When combined with a stereoscopic display as well as depth cameras, we believe that multi-touch technology can form the basis for a next generation of 3D user interfaces. Several research groups have begun to explore the potential, limitations, and challenges of this and other 3D touch environments, and first commercial systems are already available.

The goal of the seminar "Touching the 3rd Dimension (T3D)" is to address the research and industrial challenges involved in exploring the space where the flat digital world of surface computing meets the physical, spatially complex, 3D space in which we live. The seminar will provide a common forum to attract groups of conference attendees who share their visions of the future and recent results in the area of improving 3D interaction and visualization by taking advantage of the strengths of advanced multi-touch computing.

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1 Executive Summary

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Touching the 3rd Dimension

In recent years interactive visualization of 3D data has become important and widespread due to the requirements of several application areas. However, current user interfaces often lack adequate support for 3D interactions: 2D desktop systems are often limited in cases where natural interaction with 3D content is required, and 3D user interfaces consisting of stereoscopic projections and tracked input devices are rarely adopted by ordinary users.

Touch interaction has received considerable attention for 2D interfaces, and more recently for 3D interfaces. Many touch devices now support multiple degrees of freedom input by capturing multiple 2D contact positions on the surface as well as varying levels of pressure and even depth. There is great potential for multi-touch interfaces to provide the traditionally difficult to achieve combination of natural 3D interaction without any instrumentation. When combined with a stereoscopic display as well as depth cameras, multi-touch technology have the potential to form the basis for a next generation of 3D user interfaces.

Our Dagstuhl seminar *Touching the 3rd Dimension* focussed on bringing together researchers from a diverse set of fields of Computer Science to discuss the next generation of user interfaces based on multi-touch technology as well as 3D visualization. It is envisaged that such user interfaces will be fundamentally different to the current multi-touch systems that are being deployed in mobile devices, desktop environments as well as entertainment systems. First, future stereoscopic displays will work without the need for users to wear cumbersome 3D stereo glasses. In this context autostereoscopic displays have already been deployed for personal working spaces as well as entertainment systems, but are still rarely used due to technical limitations such as low resolution and lacking multi-viewpoint support. Second, future multi-touch technology will not be limited by planar screens, but touch surfaces may be of arbitrary shapes. Furthermore, touch interactions in space will be possible, while still providing the user haptic feedback, for example, by the usage of air pressure devices.

Mult-touch Interaction

Tangible user interfaces (TUIs) augment digital information and computation by physical form and thus help to activate the sophisticated skills, which people have developed for sensing and manipulating their physical environments, for the exploration of virtual worlds. In this context multi-touch technology is one of the most interesting current developments in human-computer interaction which allows users to interact via a touch screen without the need of conventional input devices (e. g., mouse, keyboard). In contrast to standard touch screens that recognize only a single touch point, multi-touch screens recognize multiple simultaneous touch points. Recently presented user interfaces such as Apple's iPhone or iPad, Microsoft's Surface or Kinect, or Jeff Han's work on multi-touch sensing based on frustrated total internal reflection (FTIR) prove the relevance of the emerging field of multi-touch enabled surfaces. Currently, most of people's sensing and manipulation skills are not used when interacting with digital worlds. Multi-touch builds upon those skills and situates the physically-embodied digital information on the multi-touch enabled screen, thus helping the user to interact in a natural way while supporting tactile feedback.

Several research groups have analyzed how humans interact with multi-touch surfaces, and new interaction techniques, in particular for 2D interactions (e. g., panning, rotating, zooming) have been proposed. Although some researchers have implicitly addressed the interaction with 3D data, 3D interaction, in particular with stereoscopic displayed data, has not been examined in depth until now.

3D Visualization

Most 3D user interfaces are applied only in highly specific application scenarios within some virtual reality (VR) laboratories. To some extent this is certainly due to the fact that interaction of humans with synthetic 3D environments still suffers from many drawbacks, and numerous problems have not finally been resolved. Devices with three or more degrees of freedom may provide a more direct interface to 3D manipulations than their 2D counterparts, but using multiple DoFs simultaneously still involves challenges. Since most often 2D interactions are performed best with the WIMP metaphor and 2D devices supporting only two DoFs (e. g., mouse and keyboard), 3D user interfaces are usually inappropriate to accomplish tasks requiring exclusively or mainly two-dimensional control. However, two-dimensional desktop systems are often limited in cases where natural interfaces are desired, which enable users to interact like in the real world. In such cases, VR systems using stereoscopic projections of three-dimensional synthetic worlds and tracking technologies support a better exploration of complex data sets. When stereoscopic display is used, each eye of the user perceives a different perspective of the same scene. With using stereoscopic displays, objects can be displayed with different stereoscopic *parallax paradigms*, i. e., negative, zero, and positive parallax, resulting in different stereoscopic effects. Objects with identical and congruent projections in both half-images have *zero parallax* and will appear to be at the same depth as the screen, objects with *negative parallax* appear in front and objects with *positive parallax* behind the projection screen.

However, although binocular disparity provides important depth cues, interaction with stereoscopically displayed objects is still a challenging task, in particular when the interaction is restricted to a 2D touch surface. Objects having zero parallax are displayed monoscopically and therefore are ideally suited for multi-touch interaction. Objects with positive or negative parallax appear behind respectively in front the touch screen and therefore cannot be accessed directly; since interaction is restricted to the screen plane either the screen limits the reach of the user or the hands may interfere with the stereoscopic effect.

However, several research groups have begun to explore the potential, limitations, and challenges of this and other 3D touch environments, and first commercial systems are already available. The goal of this seminar is to address the research and industrial challenges involved in exploring the space where the flat digital world of surface computing meets the physical, spatially complex, 3D space in which we live. The seminar provided a common forum to foster discussion among scientists, designers, manufactures and other participants working in several areas of HCI addressing the associated research questions, such as design and manufacturing of stereoscopic touch surfaces, 3D interaction techniques, evaluation methodologies, social impact, collaborative scenarios, and emerging application areas, to share their visions of the future and recent results in the area of improving 3D interaction and visualization by taking advantage of the strengths of advanced multi-touch computing.

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3 Overview of Talks

3.1 Investigating the Potential Benefits and Limitations of Stereoscopic 3D Displays for Secondary Viewing Tasks

Elisabeth André (Universität Augsburg, DE)

Numerous studies have been conducted to investigate the potential benefits of stereoscopic displays compared to standard 2D displays in application fields, such as medical surgery, computer games or assembly tasks. In the talk, we will present a number of studies we conducted to evaluate the effectiveness of stereoscopic displays in situations where the users are not able to devote their full attention to the stereoscopic displays due to higher prioritized tasks that have to be conducted in parallel. On the one hand, stereoscopic displays offer the advantage that a third dimension may be employed to encode information. On the other hand, a user that views information located at different depth levels may be distracted from the main task. As a consequence, the question arises of whether and how the special features of stereoscopic display may support the perception of information in situations where the user is busy with a primary task.

3.2 Stereo vs. One-Eyed Cursors for 3D Pointing and Implications for Touch Interfaces

Wolfgang Stuerzlinger (York University – Toronto, CA)

Joint work of Robert Teather, Wolfgang Stuerzlinger

We compare remote pointing and mouse pointing techniques using both a stereo- and mono-rendered cursor in a Fitts' law pointing experiment with varying target depths in a 3D scene. Results indicate that mouse-based techniques perform best and that the one-eyed cursor is beneficial only for some pointing techniques. We discuss the implications for 3D touch interfaces. Details are given in [1].

References

1 Robert Teather, Wolfgang Stuerzlinger, *Cursors for 3D Pointing*, Proc. of 3DCHI, 5–12, 2012.

3.3 Eye can see in 3D

Sophie Stellmach (Universität Magdeburg, DE)

Joint work of Sophie Stellmach, Raimund Dachselt

Using eye gaze for interacting with digital systems is not only fascinating, it also has great potential to support natural and fast interactions. In my talk, I will discuss how the interaction with virtual 3D interfaces may benefit from the consideration of a user's visual attention. On the one hand, 3D UIs can benefit from diagnostic eye tracking studies on how users perceive presented content. On the other hand, the consideration of a user's gaze as a supporting input channel may provide a more immersed and natural user experience with virtual 3D environments. Further details can be found in [1].

References

1 Sophie Stellmach, Raimund Dachselt, *Looking at 3D User Interfaces*, Proc. of 3DCHI, 95–98, 2012.

3.4 THE X-RAY Deutsches Röntgen Museum – A Case Study

Sina Mostafawy (rmh new media gmbh – Köln, DE)

The German X-Ray Museum was founded in 1930. It shows a unique collection about to the life of Wilhelm Conrad Röntgen and the discovery of X Rays. The museum with over 2.400 sqm contains nummerous original exhibits and interactive installations for the visitors. Our company rmh, had the honor to produce most of the interactive installations of the museum. The talk presents the production of these installations in terms of software, interaction concepts and general difficulties with permanent installtions. We produced 3D animations, realtime installations, camera- and infrared based interactive devices. We also developed custom designed X Ray shader for the realtime content. The talk also targets the change of expectations of the customers and visitors in recent years, from classical exhibits to modern interactive presentations

3.5 Touching the 3rd Dimension "in the Wild" – Problems, Challenges and Perspectives

Johannes Schöning (DFKI Saarbrücken, DE)

In our talk we would like present a few examples of multi-touch application that allow non-expert users to interact with 3D scenes. The examples – one installed on an 82" multi-touch screen in a retail store and the other used in an educational scenario – provide interesting insights, how people interact with 3D data "in the Wild". Still problems remain, because the interaction with a 3D scene is more complex than the interaction with 2D scenes on interactive tables. Therefore we try to provide some insights on current challenges from an end-user perspective.

3.6 Touching the 3rd Dimension: Virtual Reality at your fingertips?

Sebastian Knoedel (DIOTASOFT S.A.S. – Orsay, FR)

User interaction with virtual objects presented in an augmented environment on a mobile device (tablet) still is a challenging especially in a mobile context. During this talk, we will present our prototype system Selltic, that provides markerless augmented reality experience, using vision based tracking. The system is work in progress and we are exploring the possibilities and limitations of such a system.

3.7 I don't buy 3DUI

Andreas Butz (LMU Munich, DE)

I personally have severe doubts about 3DUIs for abstract data. In this dinner-talk type of presentation I'd like to trigger a vivid discussion about what makes sense in 3DUI and what not.

3.8 Out-of-the-Box Technologies for Interactive Exhibitions

Gerd Bruder (Universität Würzburg, DE)

In this talk we present out-of-the-box technologies for engaging users in semi-immersive interactive applications with three-dimensional content displayed on a multi-touch enabled interactive table with stereoscopic display and Kinect tracking. Details are given in [1].

References

1 Martin Fischbach, Marc Latoschik, Gerd Bruder, Frank Steinicke, *smARTbox: Out-of-the-Box Technologies for Interactive Art and Exhibition*, Virtual Reality International Conference (VRIC). ACM, 2012.

3.9 Co-location and tangibility in multi-user virtual reality

Alexander Kulik (Bauhaus-Universität Weimar, DE)

Joint work of Alexander Kulik, Bernd Fröhlich

The exploration of virtual objects and environments with direct body motion promotes the illusion of their physical presence – even more so if multiple users share and confirm this experience. However, the displayed computer graphics cannot be grasped and manipulated directly. Physical props are a viable option to add tangibility to the intangible, but they also introduce a second, displaced coordinate system, which breaks with the co-location of the physical and the virtual interaction space. I will illustrate these issues with various scenarios which we are exploring with our multi-user virtual reality system. Details are given in [1].

References

1 Kulik A., Kunert A., Beck S., Reichel R., Blach R., Zink A., Froehlich B. *C1x6: A Stereoscopic Six-User Display for Co-located Collaboration in Shared Virtual Environments*, ACM Transactions on Graphics 30, 6, Article 188, 12 pages, 2011.

3.10 Touch in Immersive Virtual Reality

Anthony Steed (University College London, UK)

Immersive virtual reality creates the illusion of a surrounding, inclusive world for the user. What is the role of touch in this illusion? Whilst current tactile and force simulators are crude and a long way off generating a fully "immersive" touchable environment, we often overlook the fact that the brain is very flexible. To provoke some debate I propose to discuss a study that shows that the feeling of touch can be generated from visual and audio feedback only, and that the brain can't easily determine discrepancies between vision and physical motion.

3.11 Embodied interaction

Antti Oulavirta (MPI für Informatik – Saarbrücken, DE)

Embodied interaction refers to a class of interaction techniques that exploit the human perceptual-cognitive capacities that evolved for action in the physical world. In this talk, I review recent work on mobile AR techniques that allow accessing geo-referring digital information. First evidence suggests that these techniques can radically lower the demands of search-and-select tasks.

3.12 Concepts and Techniques for Intelligent, Interactive, and Multimodal Interfaces

Marc Latoschik (Universiät Würzburg, DE)

Novel human-computer interfaces incorporate a multitude of different input and output modalities. The development of such interfaces rquires the combination of multiple methods and techniques from several fields of research. While there is alway a high interest in new and interesting prototype interaction systems, the engineering approaches seem to receive notably less attention. This is in sharp contrast to recent developments in core computer science areas like software engineering and programming language research. In addition, it weakens important non-functional requirements like reproducibility, reusability, portability, and customization. Possible reasons for this imbalance are investigated. The talk illustrates typical challenges faced during the development of multimodal intelligent interfaces. It highlights three recent development techniques which are highly advantageous during system design and implementation and which strengthen an emphasized engineering view taking into account important non- functional requirements.

3.13 Hybrid User Interfaces for Visualizing Urban Data

Steven K. Feiner (Columbia University, US)

How can multiple different display and interaction devices be used together to create an effective augmented environment? We will present prototype hybrid user interfaces being developed at Columbia's Computer Graphics and User Interfaces Lab that combine a 2D multi-touch tabletop display with tracked 3D eyewear and hand- held displays. Our goal is to support a rich information space in which users who see only the tabletop can interact effectively with users wearing eyewear or holding displays.

3.14 Why T3D?

Daniel Keefe (University of Minnesota, US)

Joint work of Dane Coffey, Bret Jackson, Chi-Lun Lin, Arthur G. Erdman, Daniel F. Keefe

I expect that each of us attending this Dagstuhl seminar has developed some exciting and innovative techniques for touching the 3rd dimension (T3D). What drives us to do this? Why T3D? For me, one of the most important answers lies in supporting human creativity. Physical action and touch seem to match and even enhance creative human activities in ways that traditional computing interfaces do not. In this talk, I will describe some of the recent T3D applications we have developed at the University of Minnesota Interactive Visualization Lab. In addition to describing some of the technical challenges in this work, I am excited to also discuss with the community how interfaces in this style might be used to enhance human creativity, drawing inspiration and methodologies from both the psychology of creativity and the emerging subfield of computational creativity.

Further details are given in [1].

References

1 Dane Coffey, Bret Jackson, Chi-Lun Lin, Arthur G. Erdman, Daniel F. Keefe, *Immersive VR Touch Workbenches: Applications in Engineering and Art*, Proceedings of 3DCHI, 31–34, 2012.

3.15 A sketch-based interface for annotation of 3D brain vascular reconstructions

David Selosse (INRIA Nord Europe, FR)

Within the medical imaging community, 3D models of anatomical structures are now widely used in order to establish more accurate diagnoses than those based on 2D images. Many research works focus on an automatic process to build such 3D models. How-ever automatic reconstruction induces many artifacts if the anatomical structure exhibits tortuous and thin parts (such as vascular networks) and the correction of these artifacts involves 3D-modeling skills and times that radiologists do not have. This article presents a semi-automatic approach to build a correct topology of vascular networks from 3D medical images. The user interface is based on sketching; user strokes both defines a command and the part of geometry where the command is applied to. Moreover the user-gesture speed is taken into account to adjust the command: a slow and precise gesture will correct a local part of the topology while a fast gesture will correct a larger part of the topology. This allows to correct the anatomical aberrations or ambiguities that appear on the segmented model in a few strokes.

3.16 Touching Non-Surface Data in Medical and Scientific Visualization

Karljohan Lundin Palmerius (Linköping University, SE)

Touch technologies are usually associated with the haptic rendering of surfaces, for example for the palpation in surgery simulation. In this talk I would like to share our experience on the use of touch as an information channel in interactive visualization of volumetric data, as in medical and scientific visualization. This can be for example data from Computed Tomography (CT) or Computational Fluid Dynamics (CFD). I will bring up successful examples as well as important aspects of the design of the haptic feedback.

3.17 3D Interaction in Surgical Planning and Training

Bernhard Preim (Universität Magdeburg, DE)

Modern surgical planning heavily involves interactive use of 3D models. Essential interaction tasks include 3D rotation, clipping, defining more complex cut geometries, and measurement. For planning endoscopic interventions, users want to see the spatial relations inside the human body in a similar way like in reality. We discuss the use of 3D input devices for such tasks. Minimally-invasive procedures, such as the insertion of stents, catheters or biopsy needles requires an in-depth understanding of the surrounding anatomy. Haptic user interfaces enable an adequate support to gain this understanding. As a final use case, we consider implant placement, where an implant needs to be fitted precisely, e.g., in the middle ear as hearing aid. This is an instance of an object-placement task that may be supported by a combination of a direct-manipulative interaction and snapping.

3.18 3D Interaction on and above the surface

Florian Daiber (DFKI Saarbrücken, DE)

With the increasing distribution of multi-touch capable devices multi-touch interaction becomes more and more ubiquitous. Especially the interaction with complex data (e.g. medical or geographical data), which until today mostly rely on mice and keyboard input or intense instrumentation, can benefit from this development. Moreover current technological trends in 3D stereoscopic displays are promising because they allow a better presence by providing an additional depth cue. Multi-touch interaction offers new ways to deal with 3D interaction allowing a high degree of freedom (DOF) without instrumenting the user. This talk will discuss multi-touch and gestural 3D interaction on and above interactive surfaces and explore the design space of interaction with stereoscopic data. Details are given in [1].

References

1 Florian Daiber, Dimitar Valkov, Frank Steinicke, Klaus Hinrichs, Antonio Krüger, *Towards Object Prediction based on Hand Postures for Reach to Grasp Interaction*, Proceedings of 3DCHI, 99–107, 2012.

3.19 Multi-Touch Gestures for 3D Modeling and Animation

Tanja Doering (Universität Bremen, DE)

In this talk I will present a multi-touch gesture set for 3D modeling and animation on interactive surfaces. The presented system implements techniques for one-handed 3D navigation, 3D object manipulation and time control. This includes mappings for layered or multi-track performance animation that allows the animation of different features across several passes or the modification of previously recorded motion. The talk will further discuss how unimanual techniques can be combined for efficient bimanual control and propose techniques that specifically support the use of both hands for typical tasks in 3D editing. More details are given in [1].

References

1 Tanja Döring, Hidir Aras, Benjamin Walter-Franks, Marc Herrlich, Patrick Rodacker, Alena Penner, Rainer Malaka, *Using Gestural Interaction on Mobile Phones for Navigating 3D Information Spaces on Interactive Walls*, Proceedings of 3DCHI, 63–66, 2012.

3.20 A New Perspective on Hand Gestures and Wearable Applications

Sven Kratz (LMU München, DE)

Joint work of Sven Kratz, Michael Rohs

Integrating depth cameras into handheld and wearable devices allows capturing 3D interactions when mobile. In this talk I will present ShoeSense and PalmSpace, two systems that highlight some of these possibilities. ShoeSense is a wearable system consisting in part of a shoe-mounted depth sensor pointing upward at the wearer. ShoeSense recognizes casual and relaxed as well as large and demonstrative hand gestures. In particular, we designed three gesture sets (Triangle, Radial, and Finger-Count) for this setup, which can be performed without visual attention. PalmSpace is a mobile phone equipped with a depth camera. It enables mid-air gestures in proximity of the device to increase the number of degrees of freedom and alleviate the limitations of touch interaction with mobile devices. We conducted a user study to compare 3D rotation tasks using the most promising two designs for the hand location during interaction – behind and beside the device – with the virtual trackball, which is the current state-of-art technique for orientation manipulation on touchscreens.

3.21 Touch Interaction with 3D SciVis and the Question of Gestures vs. Postures

Tobias Isenberg (University of Groningen, NL)

Joint work of Tobias Isenberg, Mark Hancock

A number of approaches for direct-touch interaction with 3D SciVis data have recently been proposed. In this context, interestingly, people mostly talk about "gestures" to categorize this touch interaction. When one wants to combine several of these techniques into integrated interaction systems, however, the term of a "gesture" could be seen as problematic, and I will talk about why. I will show how making a difference between postures and gestures can be beneficial and how, in SciVis and other 3D touch interaction, in most cases postures are being used due to the directly-manipulative interaction they facilitate. Details are given in [1].

References

1 Tobias Isenberg, Mark Hancock, *Gestures vs. Postures: 'Gestural' Touch Interaction in 3D Environments*, Proceedings of 3DCHI, 53–62, 2012.

3.22 Direct 3D Modeling On and Above a Stereoscopic Multitouch Display

Bruno Rodrigues De Araujo (University of Lisbon, PT)

Joint work of Bruno Rodrigues De Araujo, Gery Casiez, Joaquim Jorge, Martin Hachet

We present a semi-immersive environment for conceptual design where virtual mockups are obtained from gestures we aim to get closer to the way people conceive, create and manipulate three-dimensional shapes. We developed on- and-above-the-surface interaction techniques based on asymmetric bimanual interaction for creating and editing 3D models in a stereoscopic environment. Our approach combines hand and finger tracking in the space on and above a multitouch surface. This combination brings forth an alternative design environment where users can seamlessly switch between interacting on the surface or in the space above it to leverage the benefit of both interaction spaces. Further details can be found in [1].

References

1 Bruno De Araujo, Géry Casiez, Joaquim Jorge, Martin Hachet, *Modeling On and Above a Stereoscopic Multitouch Display*, Proceedings of 3DCHI, 79–86, 2012.

4 Working Groups

Before the seminar, we initiated a survey among potential participants in which open questions and future research directions in this field were identified. During the seminar, the principal investigators invited by the organizers introduced their projects and visions in presentations. In addition, we organized panel discussions about certain aspects of the addressed topics, such as future developments of multi-touch or stereoscopic technology, perceptual limitations etc. Finally, we arranged several workshop slots in which a group of participants will discuss certain open research questions.

During the seminar, we considered three key areas related to the next generation of 3D multi-touch user interfaces:

(i) **SYSTEM AND TECHNOLOGY: Design of 3D Touch Surfaces** Since the use of multi-touch interaction with 3D data is a novel research topic there are few commercially available systems that are explicitly designed for the visualizing and interacting with 3D information. There are special requirements for systems that support, for example, multi-touch input and stereoscopic output, which are still being determined as research in this area advances.

(ii) **INTERACTION: 3D Interaction with Touch-Sensitive Devices** Human factors is another crucial design challenge for combining touch technology with stereoscopic displays. Multi-touch interfaces can represent a good trade-off between intuitive, constrained interaction on a touch surface providing tangible feedback, and unrestricted natural interaction without cumbersome instrumentation. In particular, stereoscopic display of 3D data provides an additional depth cue, but the challenges and limitations for touch interaction in this context have yet to be sufficiently investigated. We will discuss basic as well as advanced interaction techniques that make it possible to interact with stereoscopically displayed objects using fluid, gestural input from a 2D surface.

(iii) **BUSINESS AND LEGISLATIVE: Requirements for Business Solutions** Creating a new form of 3D multi-touch user interfaces will create new business opportunities in areas such as content creation, entertainment, games, portable devices, pervasive and ubiquitous computing. It is important that the technologies created provide flexibility to enable the emergence of new business models. Traditionally work in each of these areas might emerge from different fields of Computer Science such as Human Computer Interaction and Computer Graphics and Hardware Technology.
A Dagstuhl seminar presents a unique and exciting opportunity to bring together representatives from these fields with the explicit aim of advancing the state of the art in 3D multi-touch technology. We expect the seminar to lead to the production of a book on 3D multi-touch technology, to help kickstart international collaborative research and deployments and to begin to define the shape of future user interfaces. If successful the seminar has the potential to be noted as the birth-place of new ideas in an area with enormous potential impact in academia, industry and everyday life.

5 Impression from the Seminar

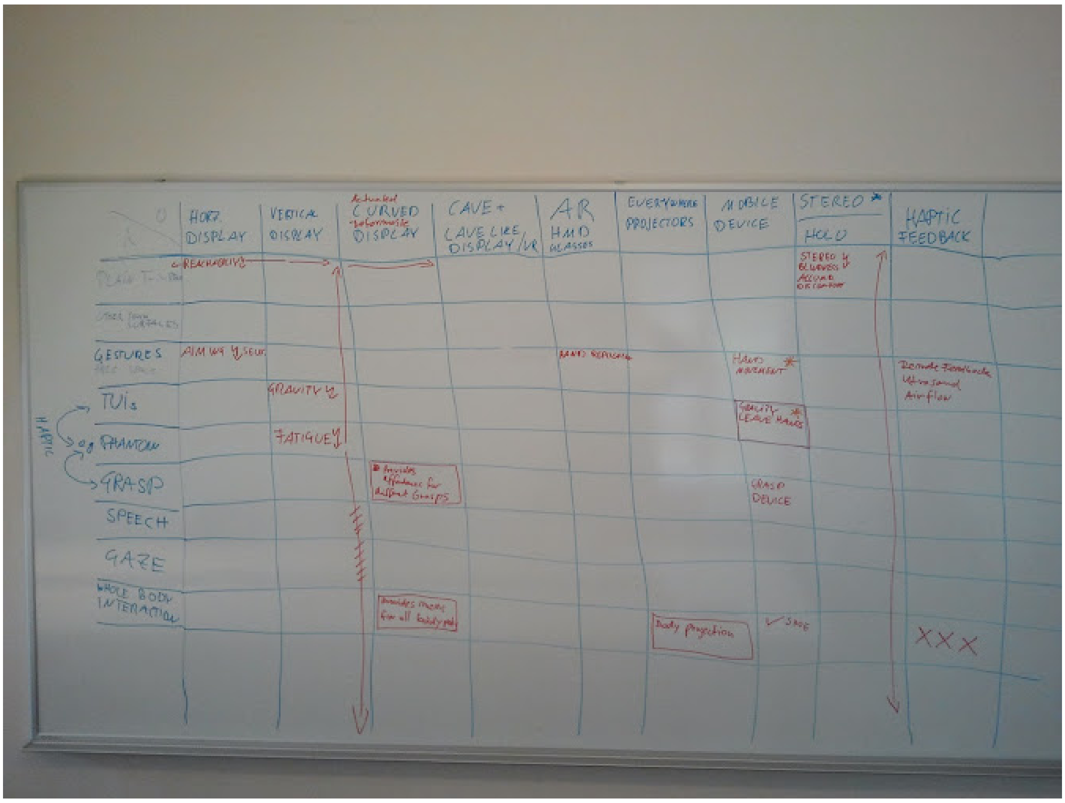

Figure 1 Some results of the workshop sessions.

Figure 2 Impression from the demos session.

Figure 3 Touching the 3rd Dimension.

Figure 4 Group discussion during the beer and wine talks.

6 Relationship to Other Workshops and Seminars

The seminar drawed from current developments in a number of workshops and conferences in the field of human-computer interaction, 3D user interfaces, multi-touch and table-top interaction, computer graphics, visualization, perception and ubiquitous and pervasive computing, most notable the Intl. Conference Series on 3D User Interfaces (IEEE 3DUI), the Intl. Conference Series on Virtual Reality (IEEE VR), the Intl. Conference Series on Computer/Human Interaction (ACM CHI), the Intl. Conference Series on Interactive Tabletop Surfaces (ACM ITS), and the ACM Symposium Series on User Interface Software and Technology (ACM UIST). Below we list a number of workshops recently held in the context of these conferences that have a direct or indirect relationship to the proposed Dagstuhl seminar topic of *Touching the 3rd Dimension*:

- Workshop on Multi-Touch Surfaces using FTIR, 2008
  `http://ifgi.uni-muenster.de/archives/multi-touch/`
- AVI Workshop on Designing Multi-Touch Interaction Techniques for Coupled Public and Private Displays, 2008
  `http://ppd08.ucd.ie/`
- CHI Workshops: Multitouch and Surface Computing Workshop, 2009
  `http://www.chi2009.org/Attending/AdvanceProgram/251.html`
- CHI Workshop: Programming Reality: From Transitive Materials to Organic User Interfaces, 2009
  `http://www.chi2009.org/Attending/AdvanceProgram/242.html`
- CHI Workshop: Natural User Interfaces: the prospect and challenge of touch and gestural computing, 2010
  `http://portal.acm.org/citation.cfm?id=1754172`
- IEEE VR Workshop: Whole Body Interaction – Technical Challenges, 2011
  `http://lister.cms.livjm.ac.uk/homepage/staff/cmsdengl/WBI2011/`
- CHI Workshop: Brain, Body and Bytes: Psychophysiological User Interaction, 2010
  `http://www.eecs.tufts.edu/~agirou01/workshop/`
- IEEE VR Workshop on Perceptual Illusions in Virtual Environments, 2011
  `http://pive.uni-muenster.de`
- ACM CHI SIG Meeting: Touching the 3rd Dimension, 2011
  `http://www.dfki.de/~fdaiber/t3d/Home.html`

None of the above events have provided the rich mix of researchers and extensive discussion opportunities that was possible in our seminar.

7 Special Issue in Computers & Graphics

During the seminar an agreement with the **Computers & Graphics Journal** has been made to publish a Special Edition on Touching the 3rd Dimension:

Papers are invited for a **Computers & Graphics journal Special Edition on Touching the 3rd Dimension**. This special edition seeks outstanding new research contributions that address the challenge of extending the fluidity and immediacy of today's flat surface computing graphics and interfaces to the physical, organic 3D space we live in.

In recent years the use of interactive 3D computer graphics has become increasingly important in applications ranging from entertainment to engineering to medicine. However, current user interfaces often lack adequate support for 3D interactions: 2D desktop systems are often limited in cases where natural interaction with 3D content is required, and 3D user interfaces consisting of stereoscopic projections and tracked input devices are rarely adopted by ordinary users.

Touch interaction has received considerable attention and success for 2D interfaces; the fluidity and immediacy of many of today's 2D touch-based interfaces is often extremely compelling. Research in Touching the 3rd Dimension seeks to understand the extent to which the fluidity, immediacy, and physicality of today's best 2D surface computing interfaces can be extended to work with 3D datasets, applications, and physical spaces.

To highlight the most exciting research in this emerging area, this special issue seeks new high-quality contributions described in excellent research papers, systems papers, survey papers, and user study/evaluation papers. All submissions will be reviewed by at least four expert reviewers. Papers should address one or more of the following topics, although authors should not feel limited by them. Unlisted but related topics are also welcome:

- 3D Interaction
- Multi-touch Technology
- Stereoscopic Displays
- Adaptive and Perception-inspired Interfaces
- Gesture-based Interfaces
- Psychophysiological Studies related to 3D
- Tangible and Passive Haptics
- 3D GUI Design and User Experience (UX)

IMPORTANT DATES

- Manuscripts due: September 1, 2012
- Initial decisions due: October 1, 2012
- Revised manuscripts due: November 1, 2012
- Final decisions on papers due: November 21, 2012
- Final versions due: December 10, 2012
- Publication: On-line January 2013 On paper: issue 37(2) March 2013

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