The 3rd Dimension of CHI (3DCHI):
Touching and Designing 3D User Interfaces

Hrvoje Benko
Microsoft Research
Redmond WA, USA
benko@microsoft.com

Antonio Krüger
Innovative Retail Laboratory,
DFKI GmbH, Saarbrücken
Germany
antonio.krueger@dfki.de

Daniel Keefe
University of Minnesota,
Minneapolis, MN 55455, USA
keefe@cs.umn.edu

Jean-Baptiste de la Rivière
IMMERSION SAS,
Bordeaux, France
jb.delariviere@immersion.fr

Frank Steinicke
University of Würzburg
Würzburg, Germany
frank.steinicke@uni-wuerzburg.de

Ken Anderson
Intel Labs
Hillsboro, OR USA
ken.anderson@intel.com

Jonna Häkkilä
Nokia Research Center
Oulu, Finland
Jonna.Hakkila@nokia.com

Leena Arhippainen
Minna Pakanen
Center for Internet Excellence
Oulu, Finland
firstname.lastname@cie.fi

CHI'12, May 5–10, 2012, Austin, Texas, USA.
ACM 978-1-4503-1016-1/12/05.

Abstract
In recent years 3D has gained increasing amount of attention - interactive visualization of 3D data has become increasingly important and widespread due to the requirements of several application areas, and entertainment industry has brought 3D experience to the reach of wide audiences through games, 3D movies and stereoscopic displays. However, current user interfaces (UIs) often lack adequate support for 3D interactions: 2D metaphors still dominate in GUI design, 2D desktop systems are often limited in cases where natural interaction with 3D content is required, and sophisticated 3D user interfaces consisting of stereoscopic projections and tracked input devices are rarely adopted by ordinary users. In the future, novel interaction design solutions are needed to better support the natural interaction and utilize the special features of 3D technologies.

In this workshop we 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 workshop will provide a common forum for researchers to share their visions of the future and recent results in the area of improving 3D interaction and UI design.

Keywords
3D User Interfaces; Virtual Reality; 3D Interaction; Multi-Touch Technology; Stereoscopic Displays

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces - Interaction styles

Introduction & Motivation

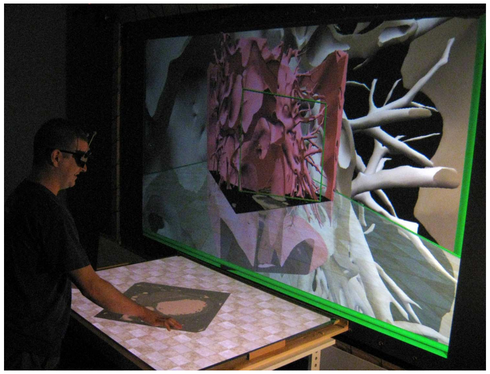
Within past few years, 3D technology has made its appearance through several areas of entertainment and information technology – 3D movies are made in increasing numbers, 3D cameras are opening content creation possibilities, Nintendo has launched a game console 3DS with a 3D display, LG a 3D phone model, and more. Current computing applications are still heavily bound to the legacy of 2D UI design, and on the input side, 3D interaction systems are often cumbersome. Current 3D user interfaces, for example provided by virtual reality (VR) systems, consist of stereoscopic projection and tracked input devices which are often systems giving priority to immersion and equipment rather than collaboration and simplicity. As 3D is intuitively connected to our experiences with the real world, it provides means for immersive UIs and more holistic interaction design. Touch technology has received considerable attention in the last years, in particular for 2D user interfaces, but it has also great potential for exploring complex content, e.g. three-dimensional data, in an easy and natural manner. Using stereoscopic displays allow users to perceive 3D data in a more immersive way. Interacting with objects that are displayed at different depths relative to the display surface is a challenging task even in VR-based environments. In this workshop we want to address the research as well industrial challenges that arise when interacting with 3D information. Especially, we wish to consider the 3D UI design challenges, as well as interaction which is performed on a 2D or even 3D touch surface.

Related Work

Today mice and keyboards are still the primary means of navigating, exploring, and interacting with 3D UIs and complex 3D datasets, even though they are often limited for these purposes, in particular when it comes to direct manipulation. In contrast, virtual reality systems using tracking technologies and stereoscopic projections of 3D synthetic worlds have shown great potential to improve exploration of complex 3D datasets. However, the most effective methods of interacting with today's complex 3D environments are not yet known, for instance, in a stereoscopic representation of a 3D scene it may be hard to access distant objects [5,9].

The prior art in 3D GUI design has mainly considered use of desktops with 2D displays, including 3D effects such as tilting and folding windows [1]. Most 3D applications also include 2D user interface elements, such as menus, texts and images, in combination with 3D content. While 3D content usually benefits from stereoscopic visualization, 2D GUI items often do not have associated depth information. Stereoscopic output can also increase the cognitive load. Lo et al. report that with stereoscopic images, users took more time to make a decision than with a 2D presentation in an experiment, where the participants had to judge the realism of the images shown to them [7]. In [6], the use of other visual cues is recommended together with disparity effect with autostereoscopic UIs.

Today, several hardware solutions exist that allow multi-touch input on surfaces of different sizes, such as [2, 3], Apple iPad or Microsoft Surface. Although some surfaces sense pressure or depth information, the use of multi-touch in current applications for interacting with three-dimensional data sets, e.g., with geospatial data is challenging, since movements in depth are only supported rudimentarily with low resolution. While bi-



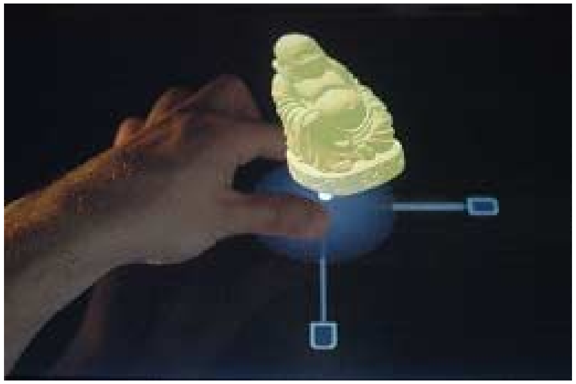


Figure 1: Example screenshots of multi-touch interaction in the context of 3D stereoscopic display: (left) A 3D medical visualization is displayed on a vertical stereoscopic screen so that it appears to the user to "float" in the air above the table. Interaction is performed by touching its "shadow" on the multi-touch table. (right) A user interacting by means of simple 2D gestures on a monoscopic touchscreen, while visualizing occlusion-free 3D stereoscopic objects floating above the surface at an optically correct distance.

manual interaction with 2D data has been studied extensively [5], it is still not clear how to use these input concepts for complex 3D data.

For this reason, recently several researchers have begun to address the problem of 3D interaction on 2D multi-touch surfaces. Schöning et al. have considered some of the challenges of multi-touch interaction with stereoscopically rendered projections, and in 2009 and 2011 IMMERSION launched commercially available multi-touch enabled stereoscopic projection displays [5, 8]. Figure 1 shows two applications on stereoscopic multi-touch displays. In other related work, Grossman et al. considered touch-based interaction, and presented a suite of interaction techniques for use with a spherical 3D volumetric display; they also proposed a taxonomy for 3D interaction on interactive table-tops [4]. One limitation of these approaches is that the interaction and visualization is constrained to almost zero parallax because the plane of the interactive surface limits the interaction space more or less to the 2D surface. Relying on a cubic multi-touch volume for indirect tactile interaction has also been investigated [4]. Valkov et al. have presented techniques to shift objects onto the 2D surface as the user moves in front of a stereoscopic projection system. Furthermore, they analyzed touch behavior for objects displayed on a stereoscopic projection screen [9].

Design and Interaction Challenges

When developing systems for 3D HCI, many design challenges arise. The workshop addresses (but is not limited to) e.g. the following issues:

3D Interaction with Touch-Sensitive Devices

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 address 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.

Perception and Action with 3D Interaction

Human factors is another crucial design challenge for combining touch technology with stereoscopic displays. We will discuss perceptual discrepancies that occur when users interact with objects displayed at different depths relative to the touch surface, and how to achieve good user experience design for such UIs. In addition it should be considered what kind of affordances, metaphors, and navigation structures need to be developed in order to design intuitive and usable 3D UIs.

Portable and Mobile Devices

The use of portable devices, especially multi-touch-enabled ones, opens up new applications for 3D UIs and interaction. 3D GUIs for small size screens require careful design. We will address mobile and portable concepts for 3D interaction, especially with stereoscopic display environments, which can make it possible for users to interact with objects e.g. in front of the display.

References

[1] Chapuis, O., Roussel, N. Metisse is not a 3D desktop! In Proc. UIST’05, ACM 2005.

[2] Coffey, D., Korsakov, F., Keefe, D. F. (2010): Low Cost VR Meets Low Cost Multi-Touch. Proceedings of International Symposium on Visual Computing, 2010.

[3] Rekimoto, J. (2002): SmartSkin: an infrastructure for freehand manipulation on interactive surfaces, Proceedings of ACM CHI, pp. 113-120.

[4] Grossman, T. & Wigdor, D. (2007), Going Deeper: a Taxonomy of 3D on the Tabletop, IEEE International Workshop on Horizontal Interactive Human-Computer Systems, pp. 137-144.

[5] Hachet M., Bossavit B., Cohe A., de la Rivière, J.B. (2012): Toucheo: Multitouch and Stereo Combined in a Seamless Workspace, ACM UIST (accepted).

[6] Huhtala, J., Karukka, M., Salmimaa M., Häkkilä, J. Evaluating Depth Illusion as Method of Adding Emphasis in Autostereoscopic Mobile Displays. In Proc. MobileHCI 2011.

[7] Lo, C. H. and Chalmers, A. 2003. Stereo vision for computer graphics: the effect that stereo vision has on human judgments of visual realism. In Proc. SCCG '03. ACM, 109-117.

[8] de la Rivière, J.B., Kervégant, C., Orvain, E., Dittlo, N. : CubTile, a multi-touch cubic interface. Proceedings of ACM VRST, pp 69 – 72.

[9] Valkov, D., Steinicke, F. Bruder, G. Hinrichs K.: (2010): 2D Touching of 3D Stereoscopic Objects, ACM CHI 2011.