The Interactive Spatial Surface - Blended Interaction on a Stereoscopic Multi-Touch Surface

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Abstract

Current touch technology provides precise and accurate large multi-touch surfaces, which allow multiple users to collaborate in these two-dimensional setups. Furthermore, recent developments in the field of display technology support visualization of three-dimensional (3D) virtual environments (VEs) in high-fidelity visual detail on these surfaces. Finally, cost-efficient depth cameras such as the Microsoft Kinect support affordable hand tracking, which enables interaction above the surface. In this paper we introduce the interactive SPAtial SurfaCE (iSPACE), a system combining classical multi-touch-based interaction with direct mid-air selection and manipulation of stereoscopically projected virtual objects. By utilizing a large state-of-the-art Ultra HD 3D display and a high-performance touch frame, the system offers high-quality collaborative exploration.

1 Background

Recently, particularly due to the revival of 3D movies in cinemas, the market of stereoscopic 3D displays experiences massive growth, giving everyone access to the formally expensive technology. Additionally, new display technologies allow a massive increase of display resolution, allowing retinal resolution even on large displays. These large 3D screens can be enhanced by adding multi-touch capabilities through so-called touch frames. These technologies dominated recent exhibitions and the entertainment market and have the potential to provide more intuitive and natural interaction setups for a wide range of collaborative scenarios, including geo-spatial applications, urban planning, architectural design, or collaborative tabletops. For (multi-)touch interaction with monoscopically displayed data, the ability to directly touch elements without additional input devices has been shown to be very appealing for novice as well as expert users (Benko et al. 2006). Recently, first commercial hardware systems with multi-touch technology and 3D stereoscopic display have been launched (Fischbach et al. 2012; Hachet et al. 2011; la

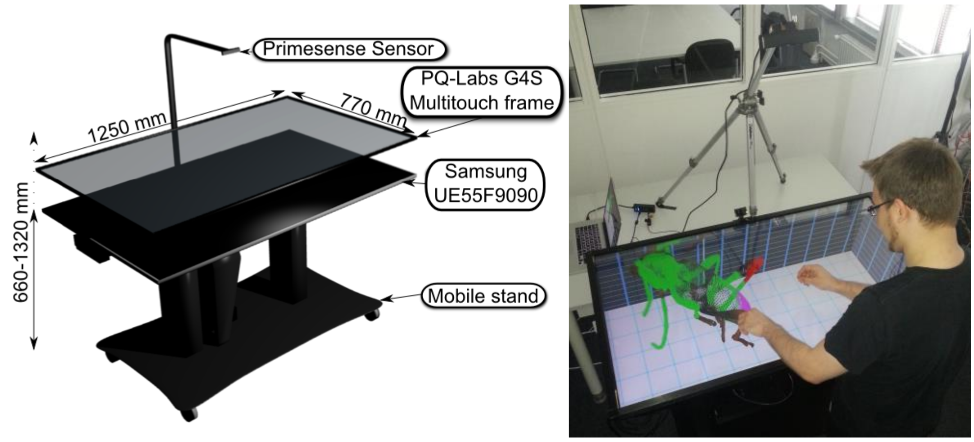

Figure 1: a) Schematic illustration of the interactive Spatial Surface in the tabletop mode. b) Illustration of work at the interactive Spatial Surface for annotating a point-cloud data set (Headtracking marker at camera position)

Rivière et al. 2010) and interdisciplinary research projects explore interaction with stereoscopic content on 2D touch surfaces (Valkov et al. 2012,2013). Moreover, an increasing number of hardware solutions provide the means to sense hand and finger poses and gestures in 3D space without input devices or instrumentation. We developed the iSPACE (see Figure 1 a)), which combines these different technology approaches, and provides enormous potential for a variety of new interaction concepts, in particular for collaborative exploration.

2 Interactive Spatial Surface Setup

As illustrated in Figure 1 a), iSPACE consists of three main components: a 3D-capable Ultra high definition (UHD) television, a portable, electrically adjustable for height, stand and the input system consisting of a cell-lightning touch frame for multi-touch-detection, a depth camera for hand tracking and an IR camera for head tracking. To display the 3D images in high-fidelity detail, we used a Samsung UE55F9000 55'' TV. It uses low weight active shuttering glasses to stereoscopically display images. The maximum resolution is 3840x2160 aka. 4k. The external setup box of the TV can be replaced for the HDMI 2.0 standard, which will allow transmitting 4K images in 3D. Currently, HD images are scaled up to the full UHD resolution. Also, unlike other setups which require expensive Quadro graphics cards, any modern graphics card with HDMI capabilities can generate the 3D scenes, either Side-by-Side or Top-Bottom and the TV automatically displays the images in a frame sequential mode. Needless to say, using a TV instead of a projector eliminated the need for calibration of mirrors or lenses and offers the advantage of being able to nearly perfectly display dark scenes, as well as bright scenes. The high resolution and the large size of the screen allow multiple users to collaborate in the same space.

For the multi-touch-recognition we decided to use a PQ-Labs G4S frame which allows smooth tracking of 32 or more touch points by utilizing the patented Cell Imaging Technology, allowing frame rates of 200 fps and detection of points with as low a size as 1.5mm. The extremely high frame rate allows tracing of quick, natural movements and the technology is less sensitive to environment lightning conditions than optical-based solutions. Hence, several users can simultaneously interact in this setup.

To be able to offer proper perspective for monoscopic and stereoscopic scenes, we decided to use the Naturalpoint TrackIR dedicated 6-DOF head tracking camera with a field of view of 51.7°, a resolution of 1850 sub-pixels/degree, a sample rate of 120 fps and a response time of 9 ms. Indeed, only a single user can perceive correct perspective in the stereoscopic case, but this perspective can be passed on to other users.

Since studies have shown that direct touch is only viable for heights up to 10 cm above the screen (Bruder et al. (2013)) and above that height mid-air interaction is feasible, we decided to expand the touch interaction through a Primesense Carmine sensor and the 3Gear NimbleSDK, which allows tracking and virtual reconstruction of a user's hands (3Gear 2014). This allows us to create new interaction concepts or adapt existing ones for interactive touch tables, for example the Handle Bar Metaphor, which users know from smart phones in a two dimensional context, can be now used in all three dimensions (Song et al. (2012)). Furthermore, the hand reconstruction may be used for physics simulations to enhance the user's sense of presence.

As illustrated in Figure 1 a), the stand features rolls, offering new interaction techniques by moving the table around in the real world. In addition, the stand is tiltable as well as adjustable in height in an electromechanical way, adding further degrees of freedom. For instance, the surface can be either used as table or as vertical screen with respect to the application domain. In both scenarios, multiple users have the possibility to stand around a table surface or vertical projection screen and collaborate. The setup even allows a smooth transition between both paradigms and therefore provides novel ways of collaboration.

3 Discussion

In this paper we introduced the iSPACE, a setup offering high-fidelity, stereoscopic 3D visualization with multi-touch for collaborative workflows. Due to blending touch interaction with mid-air interaction the setup offers potential for new interaction metaphors, which enhance the stereoscopically presented content.

As illustrated in Figure 1 b), the setup provides an interesting space for collaborative interactions, for example, in the context of collaborative point-cloud exploration and annotations. High resolution combined with stereoscopic display and head-tracking supports better depth perception. Touch interaction allows simple 3D manipulations tasks such as scaling, translation or rotations. Mid-air interaction is required to select certain volumes in the point cloud. Annotations can be performed via speech input. All concepts could be used by multiple users simultaneously.

To summarize, we believe that the iSPACE (see Figure 1 a)) provides enormous potential for a variety of new interaction concepts, in particular for collaborative exploration of 3D datasets.

References

Benko, H., Wilson, A. D., Baudisch, P. (2006). *Precise selection techniques for multi-touch screens.* In Proceedings of the SIGCHI conference on Human Factors in computing systems (pp. 1263-1272). ACM.

Bruder, Gerd; Steinicke, Frank; Stuerzlinger, Wolfgang (2013). *Touching the Void Revisited: Analyses of Touch Behavior On and Above Tabletop Surfaces.* 14th IFIP TC13 Conference on Human-Computer Interaction INTERACT, 8117, page 278--296. Springer Berlin Heidelberg

Fischbach, M., Latoschik, M. E., Bruder, G. & Steinicke, F. (2012). *smARTbox: Out-of-the-Box Technologies for Interactive Art and Exhibition.* In S. Richir (ed.), Proceedings of the 2012 Virtual Reality International Conference (pp. 19:1--19:7), : ACM.

Hachet, Martin, Benoit Bossavit, Aurélie Cohé, and Jean-Baptiste de la Rivière. *Toucheo: multitouch and stereo combined in a seamless workspace.* In Proceedings of the 24th annual ACM symposium on User interface software and technology, (pp. 587-592). ACM, 2011.

la Rivière, D., Baptiste, J., Dittlo, N., Orvain, E., Kervégant, C., Courtois, M., & Da Luz, T. (2010). *iliGHT 3D touch: a multiview multitouch surface for 3D content visualization and viewpoint sharing.* In ACM International Conference on Interactive Tabletops and Surfaces (pp. 312-312). ACM.

Song, P., Goh, W. B., Hutama, W., Fu, C. W., & Liu, X. (2012). *A handle bar metaphor for virtual object manipulation with mid-air interaction.* In Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems (pp. 1297-1306). ACM.

Valkov, D., Steinicke, F., Bruder, G., Hinrichs, K., Schöning, J., Daiber, F., & Krüger, A. (2010). *Touching Floating Objects in Projection-based Virtual Reality Environments.* In EGVE/EuroVR/VEC (pp. 17-24).

Valkov, D., Steinicke, F., Bruder, G., & Hinrichs, K. (2011). *2D Touching of 3D Stereoscopic objects.* In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 1353-1362). ACM.

3Gear Systems (2014). Nimble SDK. Retrieved June 20, 2014 from http://www.threegear.com