Touch & Move: A Portable Stereoscopic Multi-Touch Table

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Abstract

Recent developments in the fields of display technology provide new possibilities for engaging users in interactive exploration of three-dimensional (3D) virtual environments (VEs). Tracking technologies such as the Microsoft Kinect and emerging multi-touch interfaces enable inexpensive and low-maintenance interactive setups while providing portable solutions for engaging presentations and exhibitions.

In this poster we describe an extension of the smARTbox, which is a responsive touch-enabled stereoscopic out-of-the-box technology for interactive setups. We extended the smARTbox by making the entire setup portable, which provides a new interaction experience, when exploring 3D data sets. The portable tracked multi-touch interface supports two different interaction paradigms: exploration by multi-touch gestures as well a s exploration by lateral movements of the entire setup. Hence, typical gestures supporting rotation and panning can be implemented via multi-touch gestures, but also via actual movements of the setup.

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities;

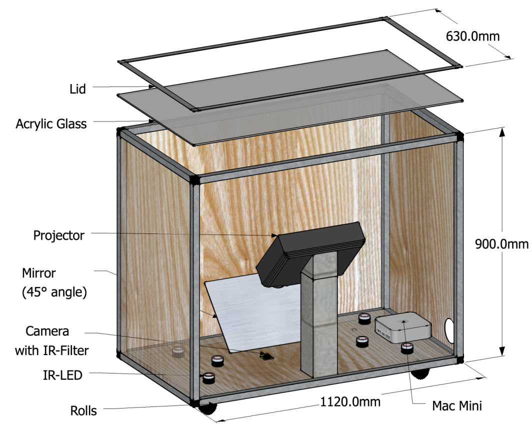

Figure 1: Illustration of the portable multi-touch enabled stereoscopic tabletop setup.

1 Introduction & Motivation

Two different technologies dominated recent exhibitions and the entertainment market: (multi-)touch-sensitive surfaces and 3D stereoscopic displays. These technologies have the potential to provide more intuitive and natural interaction setups with a wide range of applications, including geo-spatial applications, urban planning or architectural design. Since these two technologies are orthogonal, as (multi-)touch is about *input* and 3D stereoscopic visualization about *output*, the combination of these technologies provides enormous potential for a variety of new interaction concepts.

The smARTbox is one example of a setup combining multi-touch input and stereoscopic display in a tabletop surface (see Figure 1) [1]. 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, and recent results suggest that some advantages of direct touch interaction with monoscopically displayed data can be transferred to interaction in stereoscopic 3D virtual environments (VEs) [3, 4]. Passive haptics and multi-touch capabilities have both shown their potential to considerably improve the user experience. We made the smARTbox setup portable by attaching rolls to the bottom of the smARTbox, and tracked its 2D position and yaw orientation in our laboratory with an outside-in tracking system.

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The ability to combine natural multi-touch interaction with physical motions of the entire setup provides a new interaction experience. In particular, typical gestures supporting rotation and panning can be implemented via multi-touch gestures, but also via actual movements of the setup. While touch interaction has shown its potential for virtual travel and object interaction, e. g., due to passive haptic feedback provided for objects in the VE, moving the physical display surface to virtual objects of interest in the vicinity of the user provides different advantages from physical motion cues. For instance, with additional efferent copy signals from the locomotor system, proprioceptive and vestibular cues about the traveled distance and direction when moving the setup, users may benefit from path integration, route learning and spatial map buildup known from real-world navigation. Touch input is usually based on clutching movements, i. e., physical finger movements after touching the surface are mapped to relative changes of the virtual camera, but are limited by the size of the touch surface. Since, these movements have to be repeated to initiate sufficiently large virtual movements, we believe that touch-enabled setups will benefit from an additional spatial navigation method based on absolute positions of the setup in the real-world workspace. A portable touch surface has the potential to build a consistent and pervasive illusion in perceptual and motor space that two-dimensional graphical elements on the surface can be touched, and that the surface can be moved to virtual objects of interest, which appear to exist in the physical space around the user. We believe the setup provides a versatile testbed for the comparison of different embodied and exocentric interaction methods. In particular, it allows us to evaluate questions of spatial perception and cognition that arise if ego- and exocentric virtual traveling methods are used in combination. In this poster we present the technical setup as well as the interaction paradigms, which can be achieved with this setup.

2 Hardware Setup

The smARTbox is a 62cm×112cm multi-touch enabled active stereoscopic tabletop setup. The system is shown in Figure 1 and uses the *Rear-DI* principle for multi-touch detection [2]. For this, infrared (IR) light from six high-power IR LEDs illuminates the screen from behind. When an object, such as a finger or palm, comes in contact with the surface it reflects the IR light, which is then sensed by a camera. We use a 1024 × 768 PointGrey Dragonfly 2 with a wide-angle lens and a matching IR band-pass filter at 30 frames per second. We use a modified version of the NUI Group's CCV software to detect touch input on a Mac Mini server.

For stereoscopic back projection we used an 1280 × 800 Optoma GT720 projector at 120Hz, with a wide-angle lens. The active DLP-based shutter glasses are driven by the projector at 60Hz per eye. The VE is rendered on an Intel Core i7 computer with 3.40GHz processors, 8GB of main memory, and an Nvidia Quadro 4000 graphics card.

As illustrated in Figure 1, four rolls are fixed beneath the setup. Hence, the entire setup can be moved by lateral motions, i. e., forward, backward and sideward motions as well as yaw rotations. In order to track these motions and to track the user's head for view-dependent rendering, we use an optical IOTRACKER/8 tracking system with sub-millimeter precision and sub-centimeter accuracy. Therefore, we attach wireless markers to the shutter glasses as well as to a rigid body attached to the multi-touch table.

3 Panning, Rotating and Zooming

As mentioned above, the smARTbox can be moved by lateral motions, which are tracked by the optical tracking system PPT. Furthermore, multi-touch gestures can be detected on the surface. Hence, users can use both paradigms to perform typical manipulations such as panning and rotation.

3.1 Multi-Touch Gestures

(Multi-)touch interactions use physical gestures to emulate the direct manipulation of objects and provide a more natural, real-world experience when interacting with those elements on the screen. We use the well-known slide gesture for panning interactions (see Figure 2). Panning is a touch-optimized technique for navigating short distances over small sets of content within a single view. The rotate gesture simulates the experience of rotating a piece of paper on a flat surface. The interaction is performed by placing two fingers on the object and pivoting one finger around the other or pivoting both fingers around a center point, and swiveling the hand in the desired direction. In addition to these 2D translational and rotational camera manipulations, the pinch and stretch gestures are used for zooming in and out.

3.2 Physical Lateral Motions

Since the smARTbox is placed on rolls, users can perform 2D translations and 1D rotations with the system over the floor in our laboratory, which are tracked by an optical tracking system (see Figure 2). These motions are mapped in a one-to-one mapping to the virtual camera. Hence, the virtual camera can be panned and rotated in the VE by corresponding physical motions of the smARTbox. This results in the illusion of a spatial navigation method based on absolute positions of the setup in the real-world workspace like a virtual peephole.

4 Discussion

We presented the setup to five test persons. We instructed them to navigate through a VE and that they can use touch gestures as well as motions of the table for manipulating the virtual camera. The visual stimuli in this exploratory study was a virtual island displayed by Crytek's CryENGINE 3. We observed the following behavior of the test persons: At first, all subjects started to use the well-known

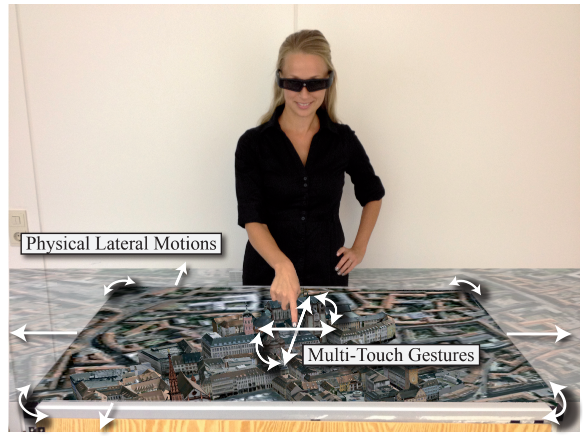

Figure 2: Two different interaction paradigms for virtual camera motions: multi-touch gestures and moving the setup via lateral motions.

touch gestures for panning, rotating and zooming. After a couple of seconds, either test persons asked if they can move the table or we instructed them to do so. Unfortunately, the form factor of the table did not show the affordance of portability in an obvious way. However, after the test persons started to move the table, they immediately understood this paradigm. After test persons started to move the table, we observed the following approach. First, they zoomed to a particular location in the VE (using multi-touch gestures) and then used movements of the table for panning and rotating. According to the subjective comments, using the lateral movement of the table has the following advantages: (i) motions of the virtual camera can be controlled more easily and (ii) no fingers on the screen disturb the visual perception of stereoscopically 3D displayed scene.

In this poster we described a portable responsive multi-touch-enabled stereoscopic out-of-the-box technology for interactive setups. We explained how interaction can be performed with two different kinds of natural interaction paradigms in parallel, which has the potential to provide new interaction methods with virtual scenes. From first experiences with the setup we assume that if a user uses the physical lateral motions, spatial cognition and understanding of the displayed scene would be improved. On the other hand, we presume that the usage of multi-touch gestures will be much more efficient in particular if larger movements are required. However, the most interesting and challenging questions arise, when both interaction paradigms are combined. In the future, we plan to examine how spatial perception and cognition is affected when similar interactions are performed with these two different interaction paradigms, e. g., if spatial memory buildup is improved via embodied physical motions with the entire setup versus clutching motions performed via touch input while the user remains static.

References

[1] M. Fischbach, M. Latoschik, G. Bruder, and F. Steinicke. smARTbox: Out-of-the-box technologies for interactive art and exhibition. In *Proc. of VRIC*. ACM, 2012.

[2] C. Müller-Tomfelde and J. Schöning. Building interactive multi-touch surfaces. In C. Müller-Tomfelde, editor, *Tabletops - Horizontal Interactive Displays*, Human-Computer Interaction Series, pages 27–49. Springer, 2010.

[3] D. Valkov, F. Steinicke, G. Bruder, K. Hinrichs, J. Schöning, F. Daiber, and A. Krüger. Touching floating objects in projection-based virtual reality environments. In *Proc. of JVRC*, pages 17–24. ACM, 2010.

[4] D. Valkov, F. Steinicke, G. Bruder, and K. H. Hinrichs. 2D touching of 3D stereoscopic objects. In *Proc. of ACM CHI*, pages 1353–1362, 2011.