A Framework for Prototyping and Evaluation of Sensor-based Mobile Interaction with Stereoscopic 3D

Florian Daiber
German Research Institute for Artificial Intelligence (DFKI)
Saarbrücken, Germany
florian.daiber@dfki.de

Andrey Krekhov
HPC Group, University Duisburg-Essen, Germany
German Research Institute for Artificial Intelligence (DFKI)
Saarbrücken, Germany
andrey.krekhov@dfki.de

Marco Speicher
German Research Institute for Artificial Intelligence (DFKI)
Saarbrücken, Germany
marco.speicher@dfki.de

Jens Krüger
HPC Group, University Duisburg-Essen, Germany
jens.krueger@uni-due.de

Antonio Krüger
German Research Institute for Artificial Intelligence (DFKI)
Saarbrücken, Germany
krueger@dfki.de

Abstract

In the last years 3D is getting more and more popular. Besides the production of an increasing number of movies for 3D stereoscopic cinemas and television, serious steps have also been undertaken in the field of 3D gaming. While the devices are market ready, few solutions for natural interaction with such devices exist. Recent smartphones have powerful processors that allow complex tasks like image processing and are equipped with various sensors that allow additional input modalities far beyond joystick, mouse, keyboard and other traditional input methods. In this paper we propose an approach for sensor-based interaction with stereoscopic displayed 3D data. In our framework various input devices can be seamlessly added for 3D user interfaces and used for rapid design and evaluation of 3D input techniques. As proof-of-concept we show the integration of sensor-based mobile devices for various 3D tasks.

Author Keywords

3D User Interfaces; Gestural Interaction; Mobile Interaction; Stereoscopic Display

ACM Classification Keywords

H5.2 [Information interfaces and presentation]: User Interfaces. - Graphical user interfaces

Introduction and Motivation

In the last years there has been an increasing interest in 3D related technology, e.g., 3D movies, augmented reality applications and gaming. Although 3D interaction has been a long research tradition, recent 3D technology lacks of natural interaction. Novel input devices such as interactive tabletops, smartphones and depth sensors have the potential to close this gap. Nevertheless, there is still research needed how these devices can be efficiently used as input for 3D user interfaces (3D UIs).

Figure 1: Sensor-based mobile interaction with stereoscopic fishtank user interface.

Only few research has addressed the problem of 3D interaction on mobile devices so far. Current 3D UIs, as they are for example provided by virtual reality (VR) systems consist of stereoscopic projection and tracked input devices. But these are often expert systems with complex user interfaces and high instrumentation. On the other hand, stereoscopic displays allow users to perceive 3D data in an intuitive and natural way. However, interaction with stereoscopic displayed objects is still a challenging task even in VR-based environments [8]. Steinicke et al. [8] discuss potentials and limitations for using multi-touch interfaces with mobile multi-touch enabled devices to interact with stereoscopic content.

In regard to interaction classification, Foley [6] proposed the following six abstract interaction tasks mainly suited for 2D: select, position, orient, path, quantify and text. Bowman [3] defined five basic interaction tasks for the 3D case: navigation, selection, manipulation, system control and symbolic input. VR applications often rely on device abstraction layers. One example is *VRPN* [9] that transfers device input over the network. Mackinlay and Card [7] introduced a taxonomy for the classification of a broad range of input devices by analyzing the underlying design space.

Recent smartphones are equipped with various sensors (e.g., camera, accelerometer, gyroscope, GPS etc.) and much research has been done in the field of sensor-based mobile interaction. Boring et al. introduced three interaction concepts to remote control a pointer on a display via scroll-, tilt- and move-gestures with a mobile phone [2] while Benzina et al. [1] explore travel-techniques for VRs using the smartphone sensors. Capin et al. present a camera-based approach to navigate through virtual environments on mobile devices [4]. Decle and Hachet present a study of direct versus planned 3D camera manipulation on touch-based mobile phones [5].

In this paper we present the *MorphableUI* framework in regard to its prototyping and evaluation features and propose sensor-based interactions with multiple mobile devices for stereoscopic 3D UIs. Furthermore, we introduce and discuss sample applications as a proof-of-concept that support various basic 3D tasks such as selection, manipulation and navigation.

Figure 2: Example device configurations for Object Editor.

Figure 3: Traditional device configurations for Fly Through.

Figure 4: Gesture-based device configurations for Fly Through.

Framework

MorphableUI is a framework that automatically generates user-tailored interfaces for arbitrary applications in arbitrary environments (Figure 5). Its interaction abstraction layer captures device capabilities and application requirements. An internal hypergraph is used to connect both sides over the network and thus, to create admissible interfaces. Detailed user behavior is logged automatically. This enables an easy and uniform evaluation in regard to preferred interfaces and user performance across all applications. Furthermore, the framework guides users through the process of the UI generation by providing according illustrations like in Figures 2, 3, 4, 6. In this way, users are able to prototype their own interfaces.

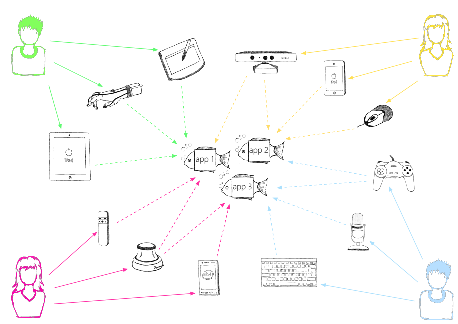

Figure 5: MorphableUI allows the participants to use all available devices to control as many applications as needed.

Interaction Prototyping

This chapter outlines the application of MorphableUI in the interaction prototyping process. Therefore, a scalable rendering environment representing a virtual fishtank is utilized (see Figure 1). Its interaction pipeline is fully controlled by MorphableUI. Users are able to choose and configure all available input devices. Three example modules of the fishtank are presented below.

Object Editor

The Object Editor allows to interact with objects within the fishtank like stones, fishes or terrain. A high degree of personalization can be achieved by adding, removing or manipulating the elements. The latter process includes the 3D interaction tasks rotation, scaling and translation. See Figure 2 for example device mappings.

Fly Through

The Fly Through mode consists of 3D navigation. Since the scenario is a fishtank, navigation corresponds to swimming and looking around. See Figures 3 and 4 for two example device configurations (traditional and gesture-based).

Presenter

The Presenter module enables 3D slide presentations. The slides are attached to swimming cuboids in order to fit into the given scenario. The interaction is straightforward, i.e., users can call next or previous slides. In addition, zooming can be performed by moving the cuboids relative to the camera position. See Figure 6 for example device configurations.

Discussion

Recent mobile technology is equipped with various sensors and powerful processors and thus is well suited even for 3D input. On the other hand, affordable depth camera sensors are available as consumer devices (e.g., Kinect, Leap Motion). Sensor-based interaction that enables users to navigate in the virtual world by interacting with the whole body which offers a rich set of metaphors and interaction for 3D. Movement in the real world such as

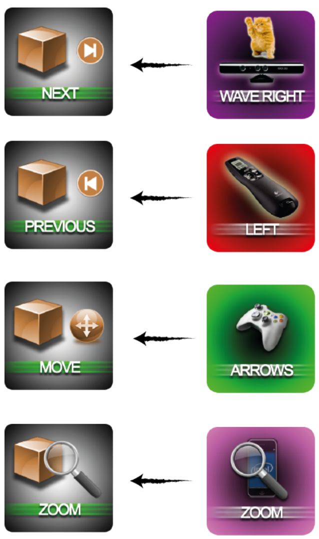

Figure 6: Example device configurations for Presenter Demo.

viewpoint changes as well as traveling can be for example directly mapped to the corresponding interactions in the virtual world.

However, the question remains how to efficiently integrate these devices to enable usable 3D applications. Interaction design for 3D UIs is highly application dependent [3]. The MorphableUI framework can be used for developing such applications in a user centered design approach or 3D UI research. The framework allows designers and researchers to quickly test many different device configurations as input in user studies and utilize the automated logging features for evaluation purposes. For example, a 3D UI can be easily evaluated in a comparative user study, e.g., mouse and keyboard setup versus gestural interaction.

Conclusion and Outlook

In this work we presented a framework for the prototyping and evaluation of sensor-based interaction with stereoscopic displayed 3D data. It allows to seamlessly add various input devices for 3D UIs and is used for rapid design and evaluation of 3D input techniques. As a proof-of-concept, a prototype that integrates sensor-based mobile devices and enables the interaction with various 3D tasks was introduced.

Initial user feedback is also promising. To adress this feedback we plan a thorough evaluation of interaction concepts that are built upon this framework. A special focus will be on touch- and gesture-based mobile interaction with stereoscopic data.

References

[1] A. Benzina, M. Toennis, G. Klinker, and M. Ashry. Phone-based motion control in VR: analysis of degrees of freedom. In *Proc. of CHI EA '11*, pages 1519–1524. ACM, 2011.

[2] S. Boring, M. Jurmu, and A. Butz. Scroll, tilt or move it: using mobile phones to continuously control pointers on large public displays. In *Proc. of OZCHI '09*, pages 161–168. ACM, 2009.

[3] D. A. Bowman, E. Kruijff, J. J. LaViola, and I. Poupyrev. *3D User Interfaces: Theory and Practice*. Addison Wesley Longman Publishing Co., Inc., 2004.

[4] T. Capin, A. Haro, V. Setlur, and S. Wilkinson. Camera-based virtual environment interaction on mobile devices. In *Proc. of ISCIS '06*, pages 765–773. Springer, 2006.

[5] F. Decle and M. Hachet. A study of direct versus planned 3d camera manipulation on touch-based mobile phones. In *Proc. of MobileHCI '09*, pages 32:1–32:5. ACM, 2009.

[6] J. D. Foley, V. L. Wallace, and P. Chan. The human factors of computer graphics interaction techniques. *IEEE Computer Graphics and Applications*, 4(11):13–48, 1984.

[7] J. Mackinlay, S. K. Card, and G. G. Robertson. A semantic analysis of the design space of input devices. *Hum.-Comput. Interact.*, 5(2):145–190, June 1990.

[8] F. Steinicke, K. H. Hinrichs, J. Schöning, and A. Krüger. Multi-Touching 3D Data: Towards Direct Interaction in Stereoscopic Display Environments coupled with Mobile Devices. In *AVI 2008: Workshop on designing multi-touch interaction techniques for coupled private and public displays*, pages 46–49, 2008.

[9] R. M. Taylor, T. C. Hudson, A. Seeger, H. Weber, J. Juliano, and A. T. Helser. VRPN: a device-independent, network-transparent VR peripheral system. In *Proc. of VRST '01*, pages 55–61. ACM, 2001.