Using the Personal Interaction Panel for 3D Interaction

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Abstract

We describe the introduction of a new interaction paradigm to 3D-applications. The everyday tool handling experience of working with pen and notebooks is extended to create a three dimensional two-handed interface, that supports easy-to-understand manipulation tasks in augmented and virtual environments. Our pair of magnetic tracked pen and pad gives sufficient tactile feedback and is familiar to inexperienced individuals, enabling them concentration on the tasks to be performed. We augment form and functionality to our device by displaying spatially aligned computer generated images to the user with see-trough head-mounted displays. On the basis of examples from object manipulation, navigation and system control we show the generality of applicability.

1. Introduction

Despite the extraordinary rapid development of computers and software for virtual reality, the acceptance of full immersive systems follows these growth rates rather hard. The aim to create the feeling of immersion by presenting convincing stimuli to the user is still not really satisfying, we are far from high-fidelity in virtual reality. Especially social aspects of full immersion may play a substantial role in denying usage by many people.

Augmented reality (AR) offers a smooth immersion by leaving the connection to real-world environments in principle untouched and superimposing computer generated imagery onto real artefacts. Social communication channels as natural speech and paralanguage are not blocked, breaking down mental barriers of applying virtual reality technology to a specific problem. Not unexpectedly, a lot of different problems arise in the investigation of augmented reality, like registration and occlusion of real world obstacles, but much research is concentrating on these topics [Baju95],[Stat96].

Another critical part of these systems lies in the interaction methods provided to the user. Whereas conventional desktop input devices, e.g. keyboard and mouse have reached a high degree of specialization during a synthetic evolutionary process, 3D input devices have still significant disadvantages. High accuracy mechanical devices are somewhat bulky or bound to certain applications and do not support generalized interaction techniques. Six degree-of-freedom mice and data gloves or suites extend the possible set of interactions by adding nearly unconstrained three dimensional movement and capturing dozens of position and orientation data, but suffer either from unsatisfying low interaction bandwidth or an overloaded metaphor like complex gesture languages. Since no direct tactile feedback of the virtual objects is provided in most systems, inexperienced users feel disoriented first and find it rather difficult to work with flying buttons, menus, "3D widgets" [Conn92] and similar metaphors floating around them.

2. Related Work

Sachs et. al. show in their paper [Sach91] a sufficiently intuitive and easy to use approach of "design directly in 3D", using two hand-held six-degree-of-freedom sensors in form of a stylus and palette. The palette is used to define a reference frame to which objects being drawn are attached. The pen is employed to draw and edit free-form curves directly in 3D. However, the system was not an immersive and head-tracked application, it was suitable for CAD shape design.

A different problem is addressed in the work *World in Miniature* (WIM) by Pausch et. al. [Paus95],[Stoa95]. Navigation in immersed virtual environments may become a difficult task for some users, since adaptation to new metaphors requires an introductory phase. The authors supply in addition to the first person view a *God's eye view* of the life-sized surrounding space on a hand-held clipboard. Navigation, locomotion and object manipulation can be achieved at different scales by directly manipulating objects on the WIM and getting feedback on the scale of immersion. Edwards and Hand [Edwa97] describe similar approaches in their work about the prototype of their user interface *MaPS* for navigation planning and viewpoint manipulation, which they implemented as an extension to immersive VRML2 [Hart96] browsers.

Even though no pen and paper paradigm is used in their implementation, Amselem [Amse95], Fitzmaurice [Frit93] and Rekimoto [Reki95] show a one-handed interaction metaphor which resembles various aspects of our work. They open a window on a shared virtual environment by giving the user hand-held display (HHD) devices showing situated graphics augmented over the real environment for browsing of large, spatially distributed, multi-media databases.

Goble [Gobl95], Kabbash [Kabb94] and many other research groups evaluated two-handed interaction as being suitable for a bunch of applications. Their conclusions imply that bimanual interaction can rise overall performance, especially in cases where asymmetric division of labour is applied to the hands. Nevertheless the application of a bimanual interface for a specific task needs careful analysis, since the enriched interface may possibly degrade the quality of interaction in some cases.

3. The Personal Interaction Panel

To represent the suitability of our tool for a wide range of interaction styles we called our hardware setup *Personal Interaction Panel* (PIP). The PIP is composed of a lightweight, notebook-sized hand-held panel and a pen. Both panel and pen are tracked in position and orientation either by standard magnetic trackers or by optical tracking. We designed concepts for different implementation levels of the panel and pen pair, depending on the supporting software and hardware environment. Ranging from a complicated pressure-sensitive flat display which can be observed with LCD shutter glasses in combination with a pen similar to a portable "Responsive Workbench" [Krüg95] to a pressure-sensitive flat panel with pen and a see-through head mounted display (HMD).

We see the viewing angle constraint of today's LCD displays to be very hindering to display three dimensional images in the space above the panel. Furthermore are most pressure sensitive panels too massive for continuous hand-held use and the device interferes with state of the art magnetic tracking systems. For these reasons we decided to implement a version, which consists of a "dumb" panel and pen in combination with a see-through HMDs. Neither pad, nor pen have any built-in hardware intelligence apart from the magnetic trackers mounted on them offering the widest spectrum of degrees of freedom in designing the interface itself and being the most flexible for rapid prototyping, software design determines the full functionality. The three dimensional imagery is presented to the user on a see-through HMD, in accordance to his or her actual viewpoint and viewing direction. Position and orientation tracking of all three parts (panel, pen and HMD) allows the correct evaluation of spatial relations for perspective matching of the real and augmented environment. A high level of augmentation and immersion is achieved, since users without HMDs do not see anything on the board, yet they recognize the panel being an input device supporting computer-human interaction. The physical properties of the devices support exclusively tactile feedback to the user, enriching the interaction.

The Personal Interaction Panel supports this mixture of the 2D desktop metaphor and the 3D display, so 2D interaction and three dimensional direct manipulation are done in parallel. Unlike many other interfaces it implements a 2D interface *in* 3D, like a notebook with its flat surface in the real world, rather than a combination of 2D *and* 3D, requiring a mental change from flat to spatial.

4. Interaction using the PIP interface

We categorized user interaction tasks in object manipulation, navigation and system control respectively. We will follow this classification and show the usability of the PIP to certain tasks, as well as it's advantages compared to other tools.

4.1 Object Manipulation

Modelling of objects has been an issue from the beginning of computer-human interaction. Working with objects directly in three dimensions rather than with 2D projections improves understanding of shape and relations. In our setup, the pen alone is used for 3D pointing-, selection operations or direct manipulation of the displayed model, where a 6D mouse is normally used. This feature is seamlessly integrated within the extended PIP functionality, so that the PIP supports a superset of "standard" 3D operations in virtual and augmented reality.

The PIP is capable to be used as a visible 3D clipboard carrying a collection of 3D (or 2D) data items, that are shown above the panel's surface and can freely be accessed by the user. Objects may be dragged out from the surface of the PIP and directly placed or moved in the augmentation (Figure 1). Selection and transformation of virtual objects is supported by either direct 3D manipulation or using widgets rooted on the panel's surface (Figure 2). Different tools which also are selected from a visual clipboard are used to make modifications to objects, like extension with additional geometry or alternation of material properties.

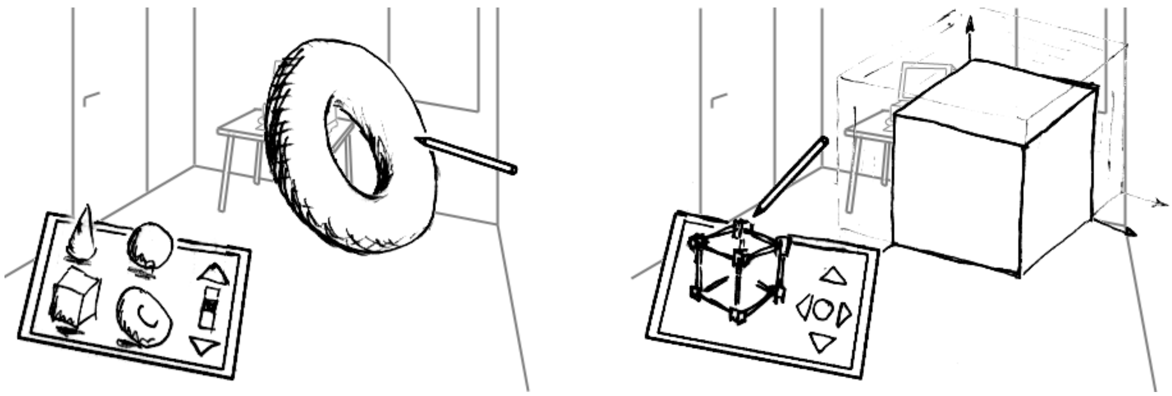

Figure 1 and 2. *"Drag & Drop" from a clipboard and PIP rooted widgets for object transformations*

4.2 Navigation

As object manipulation concentrates on handling and editing of objects, navigation is necessary for changing viewpoint position and orientation in order to explore a specific part of the environment. Additional to the own viewpoint movement supported by head tracking, navigation metaphors described in [Hinc94] are supported in our AR setup with the PIP interface. The "eyeball-in-hand" metaphor is in our case a "look where you point" image, for that virtual camera position and orientation is defined with the pen, while the off-screen rendered camera image is displayed on the panel, as shown in Figure 3. Enlarged or miniaturized views from the surroundings can be displayed on the panels surface, even from the inside of the explored objects. It is very important, that the presented PIP navigation metaphors allow the user to keep the connection to the environment without any cognitive switch, because the own view is kept and the navigation display is on the panel.

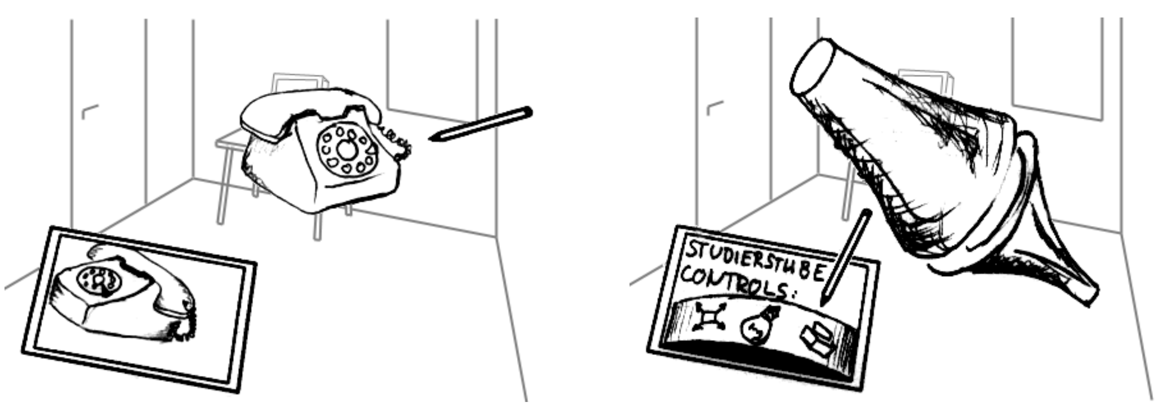

Figure 3 and 4. *Camera positioning with the pen and general system controls "inside" the augmentation*

4.3 System Control

The design of overall controls is crucial for a system, the user may not be forced to need very special skills for the general controls of the application, as he wants to concentrate on the topic of the application. Immersive augmented applications need easy controls, which have to be “inside” the augmentation. For the feeling of good immersion it is very important not to leave and join the augmentation for operations like reconfiguration of the system, starting a new session, etc. The PIP offers the possibility to contain and manipulate all the necessary controls in a desktop manner as described above or as a tool-palette (Figure 4), which groups functions and make them easily accessible.

5. Conclusion

We have introduced a multi-functional new 3D user interface, the Personal Interaction Panel, which consists of a magnetic tracked simple clipboard and pen, containing augmented information presented to the user by see-through HMDs. The low technical level the panel and pen itself allows flexible design of the interface and rapid prototyping. The natural two-handed interaction supported by this device makes the device fit to a rich variety of applications. Our initial evaluations have shown, that all test persons were familiar with the interface in a very short time. Although they were surprised by the mixture of 2D and 3D display and interaction elements on the PIP, they did understand the interface. As they were used to work with both hands, they found the two-handed interface natural.

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