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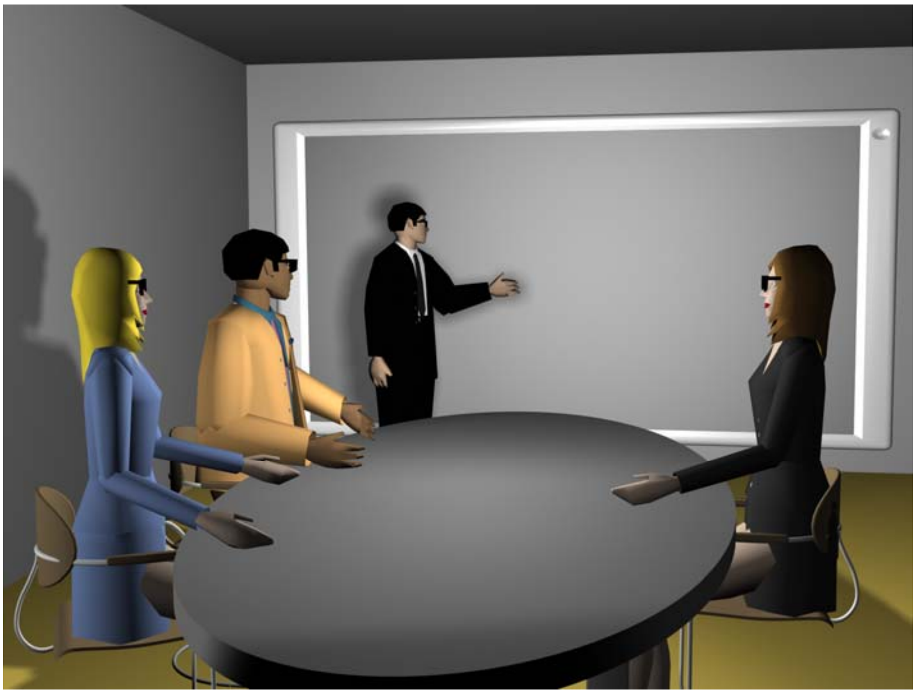
LEVERAGING TECHNOLOGY

Utilizing the Benefits of Virtual Environments



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Abstract

Over the last ten years many oil & gas companies have installed Virtual Environments in order to optimize, complement, or replace steps in their E&P workflow. The success of the deployed Virtual Reality technology varies from company to company, but not always fulfills set expectations.

The experiences made in the VRGeo Consortium also indicate that the potential of VR technology is not yet used to its full extend. Only if VR technology can clearly show its benefits over existing technology, the users are willing to adopt and integrate it into their daily workflow. In this respect, we describe by means of illustrative examples what can be done to better utilize the benefits of Virtual Environments.

Introduction

Virtual Reality (VR) technology is a quiet old technology, which exists for almost fifty years now. First applications can already be found in the sixties, e.g. the Sensorama by Morton Heilig (1962) or the first 3D head mounted display (HMD) by Sutherland (1965). Since then, a lot of serious research has been undertaken and a lot of applications have been developed. Different industries, like the automotive, air & space, and the oil & gas industry, have picked up VR technology. But even though, in most companies VR technology is still a niche technology, which needs extra justification to be implemented.

Looking at the oil & gas industry the amount and the way of VR usage varies a lot from company to company. There are a few companies that have integrated VR tools in their day-to-day E&P workflow with estimated percentage rates up to 25%. Others do not use VR technology at all or only in research projects.

The question is why VR technology is not really successful? One part of the answer to this question are different limiting factors like software support for special VR scenarios, data integration, space requirements, financial considerations, stability issues, or application complexity. These factors have to and, in our opinion, can be addressed depending on the concrete circumstances and limitations.

We think the most important part in the success of VR technology plays the user. Obviously the success of a user-centered technology is dependent on the acceptance by the user. Only if the user sees a real benefit over existing technology, he is willing to adopt it. Also, the added value of the new technology has to reach a certain threshold to compensate for the extra affords that might be necessary to change a familiar workflow. Once some key users are really convinced by the usefulness of a new technology, they will act as multipliers, so-called champions, who will convince other users of the benefits of the new technology.

In our opinion, VR setups are often not good enough to clearly show their benefits over existing technologies. Based on 10 years of VR research and development for the oil & gas industry under the umbrella of the VRGeo Consortium we are very confident that VR technology can be much more successful. In many cases it is only the small things that prevent VR setups from being convincing and from showing their real benefits. Using illustrative examples, in the following we describe some common mistakes and possible solutions to avoid them.

The examples are chosen from three different categories, which, according to our VRGeo experiences, should profit most by the use of VR technology in the oil & gas industry. Very important is the VR support of *collaboration and communication*, followed by the availability of *three dimensions*, and the usage of *modern technology*. The usage of modern technology as one important aspect of VR technology might surprise in the first place but plays a significant role for corporate image reasons and also for the employee's subjective perception of the progressiveness of his/her work environment.

The VRGeo Consortium

The VRGeo Consortium is an international consortium for the oil & gas industry (VRGeo 2008). It was established in 1998 by Adolfo Henriquez from Statoil (Norway). Current industrial members are Barco, BP, Chevron, ConocoPhilips, ExxonMobil, Hewlett Packard, Landmark, NVIDIA, Petrobras, Saudi Aramco, Shell, and StatoilHydro. The members represent both oil and gas companies and the developers of oil and gas software applications. Academic members are Christian Michelsen Research, NTNU - Norwegian University of Science and Technology, and Pontifícia Universidade Católica do Rio de Janeiro.

The aim is to develop visualization technology for geosciences applications in Virtual Environments. All research and results are embedded in our VRGeo demonstrator framework. The consortium meets twice a year at the Fraunhofer-Gesellschaft in Sankt Augustin for a review of the research results and the definition of the future research agenda.

Collaboration and Communication

Most of the tasks in the oil & gas industry are multi-disciplinary tasks with many experts from different fields involved. Virtual Environments can support such kind of collaborative tasks. For example Virtual Environments are used as a discussion and decision making environments, where team members may be distributed all over the world or they may be on-site, i.e. co-located. A so-called VR conference room, which can be found in many oil & and gas companies, represents such kind of Virtual Environment.

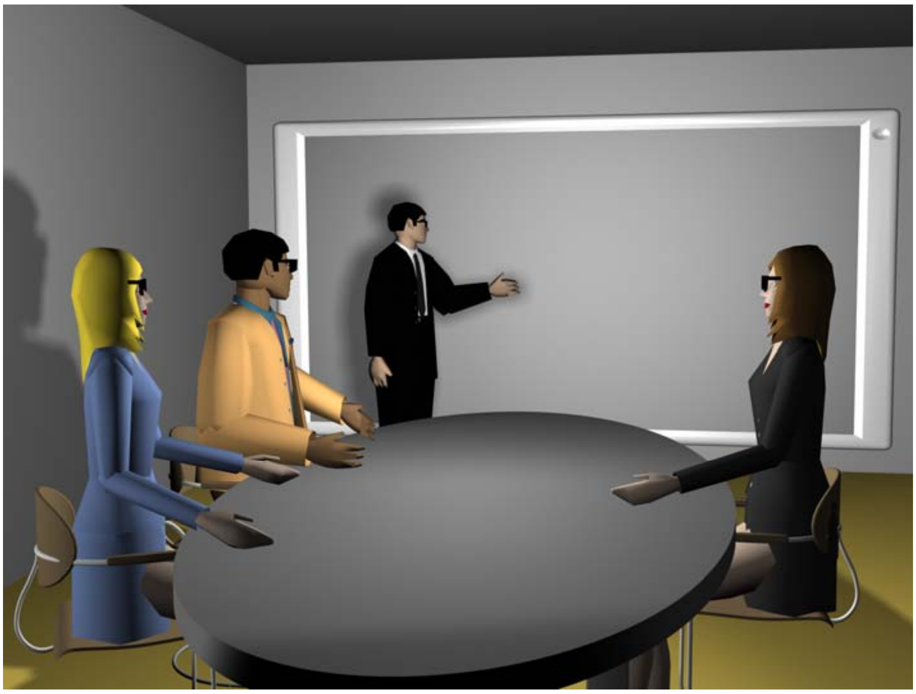

Figure 1: A typical VR conference room as found in many oil & gas companies.

Typically a VR conference room such as depicted in Figure 1 consists of a back projection wall display with stereoscopic rendering capabilities. With some meters distance to the screen there is a conference table typically shaped in a way to optimize the viewing of the screen.

In contrast to monoscopic displays, such as normal LCD screens or standard projectors in conference rooms, the perspective rendering of stereoscopic displays is based on a viewing position and direction in the real world. Ideally this position and orientation is the same as the one of the user, who is viewing the stereoscopic picture. This can be achieved by tracking the user's head position and orientation. In case of a VR conference room, where multiple users simultaneously view a stereoscopic projection, some kind of compromise is usually made to set the viewpoint for the rendering.

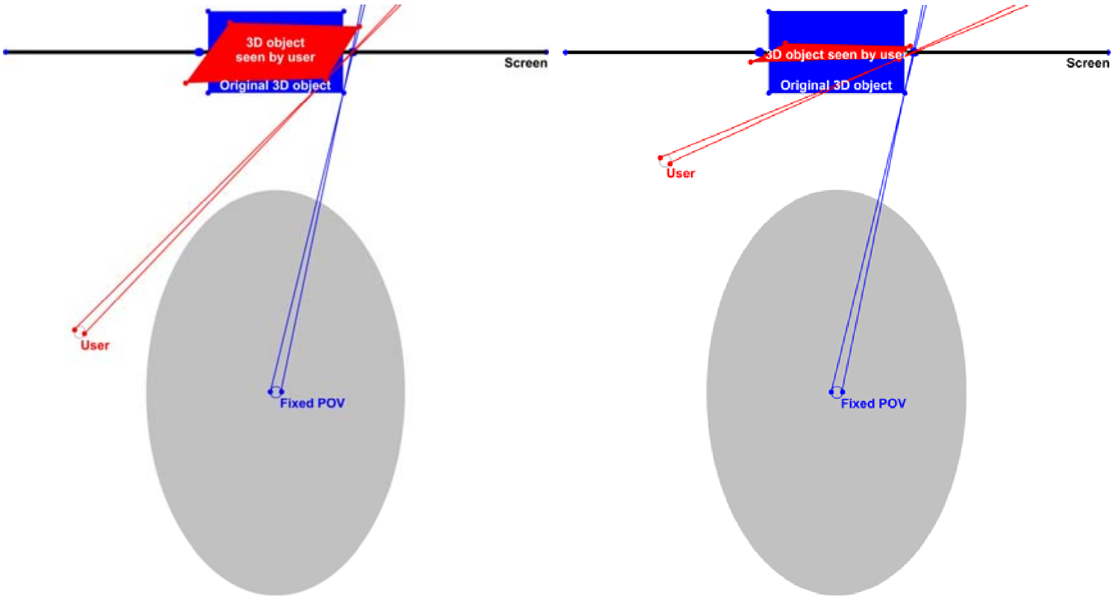

Figure 2: A rectangular object, rendered from a fixed point of view (POV) in the middle of the conference table (blue), seen from different room positions (red).

A common setup is shown in Figure 2, where the center of the rendering is set to a fixed point in the middle of the conference table. As a consequence none of the users sees a correct stereoscopic picture. As an example the figures show the distortion for a rectangular object viewed from different positions in the conference room. Especially note the amount of distortion perceived by a person standing directly in front of the screen, e.g. for interaction purposes (Figure 2, right).

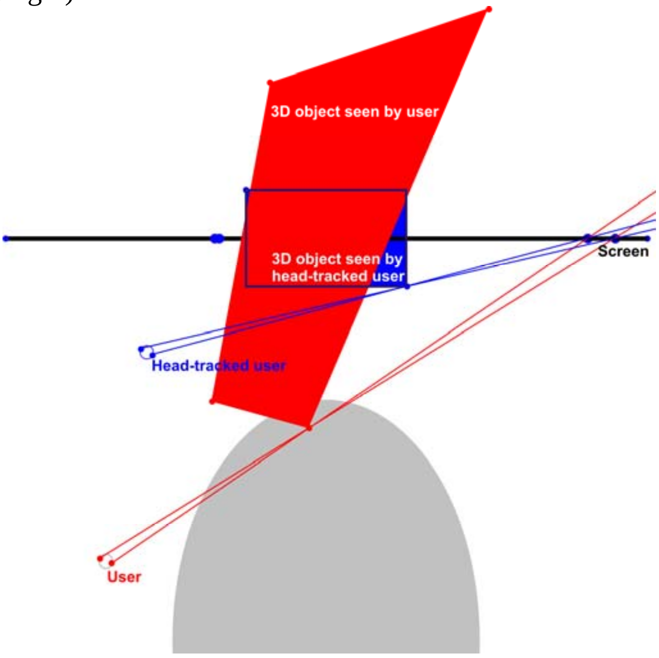

Figure 3: A rectangular object, rendered from a head-tracked user's point of view (blue), seen from seat at the conference table (red).

Another frequently used setup is to head-track one main user, who is performing all interaction and manipulation, and continuously render the picture from his/her current position and viewing direction. As shown in the example Figure 3, depending on the viewing direction of the head-tracked user, the other users perceive the rectangular object in a highly distorted way. In addition, since the main user continuously changes his/her head position and viewing direction the amount and nature of distortion permanently changes, which can lead to serious eye strain and also sickness.

The examples show that acceptable stereoscopic viewing for all users can only by achieved by a fix point perspective in the middle of the conference table. This is an excellent setup for communication purposes, which means to *talk about* the visualization, but it is not suitable to *collaboratively work with* the visualization. For this purpose we would need multiple users being able to *interact with* the virtual environment, which requires correct stereoscopic viewing for all of these users.

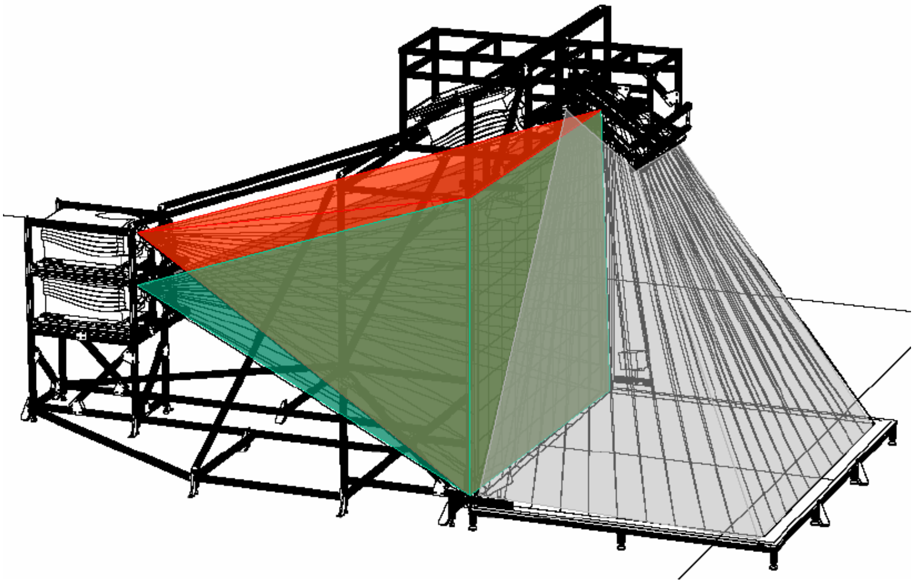

Figure 4: The TwoView display system.

For smaller numbers of users the appropriate display technology is available for some years now. For example in 2005, we introduced the TwoView display system (Figure 4), which projects an individual stereoscopic image for each of two users (Riege et al. 2005). As shown by Froehlich et al. (2005), the basic concept can also be extended to four users. The remarkable property of such kind of multi-view displays is that all users share the same manipulation space, which facilitates natural interaction with and collaborative manipulation of the same virtual scene.

In case the number of conference participants exceeds the number of available views, one solution is to distribute the views among the participants in such a way, that actively interacting users get a head-tracked view and all the other users (who sit at the conference table) share one fixed-point perspective view. It is also worth to mention, that for larger numbers of users different solutions are currently being developed. The most promising type are lightfield displays (e.g. Holografika 2008 or Jones et al. 2007), which would also end the need of stereo glasses.

Three Dimensions

To most users the most relevant attribute of a Virtual Environments is that it is a three-dimensional environment. This means that the user not only views 3D objects being displayed on a screen but perceives the virtual environment as (part of) his/her actual environment. The term “immersion” describes the degree of that perception: the more the user feels being part of the virtual environment the higher (the degree of) immersion. The obvious benefit of such kind of environments is to use it for work with three-dimensional content, such as 3D seismic data or reservoir models. This way the data becomes part of the user's (virtual) environment and is, depending on the quality of the implementation of the Virtual Environment, viewed with very good depth perception.

Having an oil & gas application running in a Virtual Environment, one also needs an interface to control the application and the system at whole, a so-called system control interface. Here the advantage of being part of a 3D environment becomes in a way a disadvantage, since most existing interfaces are made for desktop environments, based on standard WIMP interfaces ("Window", "Icon", "Menu", "Pointing device") in combination with a keyboard. There is no obvious way how to transfer that interface into a three-dimensional Virtual Environment. For example, the mouse can not be used as a 3D pointing device and the window and menu system will not work properly in a 3D environment, since is designed for a 2D desktop environment[1]. Worst of all, in contrast to the 2D desktop, there are no established standards how a 3D system control interface should look like.

This situation leads to different solutions. One the one hand there is a large variety of custom-made menu systems, which can be classified by the number of degrees of freedom (DOF), which are needed to control the menu. There are 1-DOF list or ring menus (e.g. NASA VWT 2008 or Wesche 2004), 2-DOF circular menus (e.g. Häfner et al. 1999), and even a variety of 3-DOF menu systems (e.g. Grosjean and Coquillart 2001). The look & feel of all theses menu systems is very different compared to each other as well as compared to the classic desktop menus. On the other hand there are several approaches that try to adapt a 2D widget set for the use in 3D (e.g. Andujar et al. 2006). Usually this is done by texturing a 3D plane with the widget's representations and mapping the intersection point of a ray based interaction with that plane back to the widget system as a 2D mouse position. The advantage of this approach is that dialogs and controls of an existing desktop application can be directly used in the 3D environment.

Though convenient, the latter approach has the fundamental drawback of using a widget set, which was not explicitly designed for a 3D environment. For example, not always all widgets are freely scalable, which is necessary in order to compensate for perspective scaling. On a more fundamental level an inherent problem of desktop widget sets is that selection and manipulation are a combined task that is limited by the visual representation of the widget itself. For example, for the manipulation of a slider one has to grasp the handle of the slider (selection) and then directly determine the slider position by adjusting the mouse position (manipulation). In 3D for larger distances this task becomes very complicated, since first the user has to pick the (small) slider handle and then move it to the desired position, while always carefully controlling his/her hand rotation, where smallest angle changes will result in undesired large slider movements.

To solve such kind of problems in 2007 we introduced so-called context-controls, a combined 3D control and menu system, which was explicitly designed with Virtual Environments and user-friendliness in mind (Dressler 2007). As can been seen in Figure 5 the menus are composed of equally sized blocks, which either represent a menu item, a widget, or a submenu. Selection of each of these items is done by selecting its associated block. There is no need to accurately grab parts of a widget, like a slider handle or a radio button; one just has to select the associated block. After selecting, the manipulation of a widget is done by an adequate interaction model, e.g., a slider value is changed by hand rotation. Another important property of the menu system is its positioning and resizing system. Like a windows manager for a desktop environment our positioning and resizing system tries to find a suitable position and size for the menu in 3D by considering basic conditions like the viewing

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[1] Actually it is a 2½-dimensional interface but that does not matter here.

direction of and distance to the user, other occluding objects, and the boundaries of the viewing frustum. The resizing system tries to keep the projected size of the menu constant, which ensures distant independent features, like the viewing angle on the menu, menu interaction movements, and the occlusion size of the menu. There are also some apparently simple features, which yet make huge difference to the usability of the menus. For example, the menus are semi-transparent in order to enable viewing on objects occluded by the menu or to save space, submenus do not open as a separate menus but replace the current one by a rotation animation.

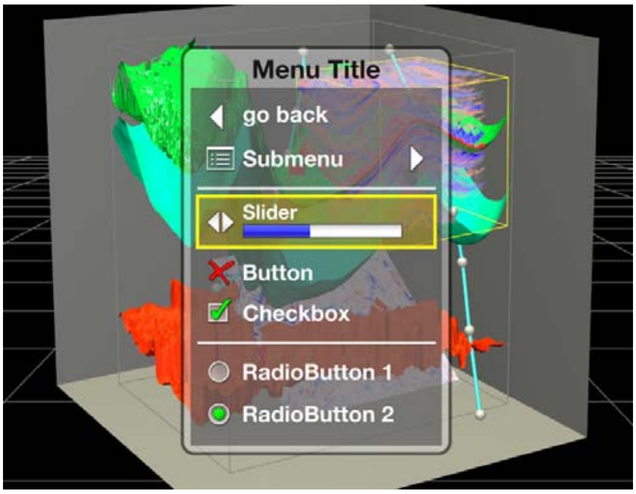

Figure 5: A Context-Control in front of 3D seismic data.

The feedback from many users and also the results of a user study has shown that the context-control concept is intuitively usable with almost no explanations. Also, the users rarely feel the need to move a menu around, which confirms the quality of our positioning and resizing system and also the effectiveness of the use of semi-transparent menus.

Modern Technology

Since VR technology is (still) considered a very modern technology, for a lot of companies one reason to deploy VR technology is to display modernity and progressiveness as part of the corporate image. However, the use of modern technology is always twofold. On the one hand we feel by using the new technology to have an advantage over others who do not have access to that technology, and on the other hand the new technology might be complicated to use and potentially cause user's anxieties to handle it. To avoid such kind of anxieties is one of the most important aspects when implementing new technology and in particular VR technology. In the end, the success of the technology is bound to the user's acceptance of it.

An example for such kind of VR technology is the variety of different devices, the user can choose from when using a Virtual Environment, such as interaction devices, I/O-devices, and (tracked) stereo glasses. Ideally the user could choose any combination of tracked device and stereo glasses and also could swap the devices with other users at any time. In most Virtual Environments this is not possible, since the pairing between tracked devices and tracked stereo glasses is fixed, which leads to confusion and strange application behavior if the paring is mixed up or when the users want to swap an interaction device.

To solve this problem we introduced a so-called association gesture to pair an interaction device with tracked stereo glasses. As shown in Figure 6, the gesture is easily described as a cell phone-like gesture, for that the interaction device is hold for some seconds close to one ear (in the vicinity of stereo glasses). This way the users of the Virtual Environment are free to choose from all available interaction devices and stereo glasses, and by a simple association gesture can tell the system, which combination they are currently using. As a feedback system we color code the pick ray, which emits from the interaction device, by the color code of the associated glasses. This way, every time a user associates a new device with his/her stereo glasses, the association is confirmed by a color change of the pick ray. This technique is especially useful for any kind of multi-user scenarios, where more than one user is head-tracked.

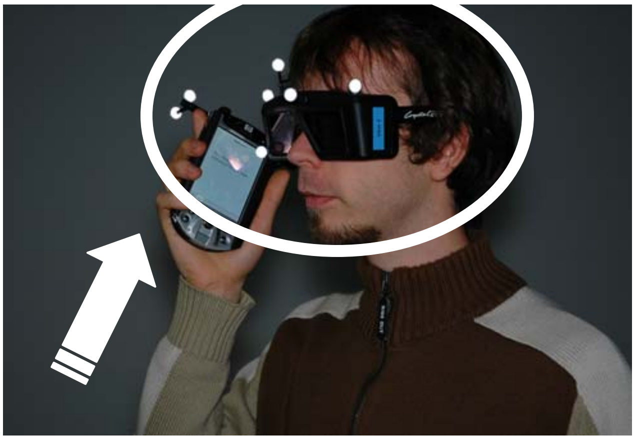

Figure 6: Cell phone-like device association gesture.

Conclusions

In this paper we have shown by means of three different examples how to improve different aspects of Virtual Environments in order to optimize the quality and usability of the Virtual Environment at whole. An accurate analysis of the application purpose of the VR technology is a requirement to realize a usable Virtual Environment setup. In particular it is most important to adapt the Virtual Environment to the needs of the users, in order to better utilize its benefits.

References

Andujar, C., Fairen, M. and Argelaguet, F. [2006] A Cost-Effective Approach for Developing Application-Control GUIs For Virtual Environments. *IEEE Symposium on 3D User Interfaces 2006 (3DUI)*, 45-52

Dressler, A. [2007] User-friendly Menu Design for Virtual Environments in an Expert Context. *Diploma thesis, TU Ilmenau*

Froehlich, B., Hochstrate, J., Hoffmann, J., Klüger, K., Blach, R., Bues, M. and Stefani, O. [2005] Implementing Multi-Viewer Stereo Displays. *WCSG 2005*, 139-146.

Grosjean, J. and Coquillart, S. [2001] Command & Control Cube: a Shorcut Paradigm for Virtual Environments. *7th EG Workshop on Virtual Environments & 5th Immersive Projection Technology Workshop (IPT-EGVE01)*

Häfner, U., Simon, A. and Doulis, M. [1999] Evaluation of Complex CAAD Data in a Virtual Environment. *3. International Immersive Projection Technology Workshop*, 157-165.

Heilig, M. [1962] The Sensorama. *U.S. Patent*, #3050870.

Holografika [2008] http://www.holografika.com.

Jones, A., McDowall, I., Yamada, H., Bolas, M. and Debevec, P. [2007] Rendering for an interactive 360° light field display. *ACM Transactions on Graphics*, **26**, 3, 40.

NASA VWT [2008] NASA Virtual Windtunnel Widgets. http://www.nas.nasa.gov/Software/VWT/widgets.html.

Riege, K., Wesche, G., Holtkämper, T. and Fröhlich, B. [2006] The Bent Pick Ray: An Extended Pointing Technique for Multi-User Interaction. *IEEE Symposium on 3D User Interfaces 2006 (3DUI)*, 63-66.

Sutherland, I. E. [1965] The Ultimate Display. *Proceedings of IFIP*, **65**, 2, 506-508.

VRGeo [2008] The VRGeo Consortium, http://www.vrgeo.org.

Wesche, G. [2004] A User Interface for Free-Form Shape Design at the Responsive Workbench. *Journal of Computing and Information Science in Engineering (Transactions of the ASME)*, **4**, 3, 178-185