Experiences with Multi-Viewer Stereo Displays Based on LC-Shutters and Polarization

Roland Blach, Matthias Bues
CC Virtual Environments
Fraunhofer IAO, Stuttgart, Germany
Roland.Blach@iao.fhg,de

Jan Hochstrate, Jan Springer, Bernd Fröhlich
Virtual Reality Systems Group
Bauhaus University Weimar
Bernd.Fröhlich@medien.uni-weimar.de

1. Introduction

Perspective projection in combination with head tracking is widely used in immersive virtual environments to support users with correct spatial perception of the virtual world. However, most projection based stereoscopic systems show a correct perspective view for a single tracked viewer only. Our intent is the development of a multi-viewer projection system for local collaboration in immersive environments. We focus on projection based systems where all users operate in the same interaction space. We present our implementation of a multi-view stereo system based on shuttered LCD-projectors and polarization. The combination of these separation techniques allows the presentation of more than one stereoscopic view on a single projection screen. We have successfully implemented shuttering of four projectors to support two users with individual perspectively correct stereoscopic views

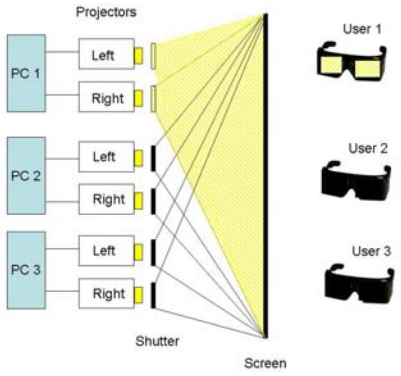

Figure 1: System principle shown for three users. The polarization is used to separate the eyes. The shutters are used to separate the user.

2. Setup

We use standard nematic liquid crystal (LC) or ferro-electric liquid crystal (FLC) shutter elements and LC-projectors to separate the individual users. Polarization is used to separate the left and right eye view. Standard LC projectors emit already polarized light, which helps to set up such a system. However, the green channel is typically polarized orthogonal to the red and green channel. We are using wave length selective half wave retarders to align the polarization of all three channels. For the left eye the polarization of the green channel is rotated by 90 degrees by the half wave plate, and for the right eye the red and blue channel are rotated by 90 degrees. Thus the polarization of all three color channels for the left and right eye are orthogonal to each other. Shutters consist of another half wave retarder embedded between two orthogonal polarization filters. Thus polarization is preserved and rotated by 90 degrees. Our setup is shown in Figure 2.

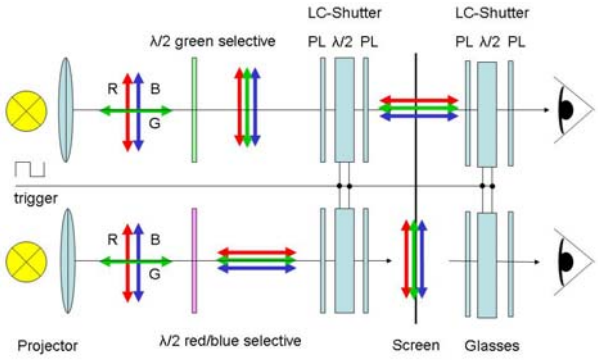

Figure 2: Filter principle for left and right eye. The projector is on the left and the users eye on the right.

The shutters in front of the projectors and the users' eyes are controlled by a custom built micro-controller circuit. The shutter clock is independent of the refresh rate of the LC projectors and we have achieved good results for three users by running between 50 and 80 Hz per user per eye.

Each projector pair for a single user is driven by one PC with a dual head graphics card. The used software is the

VR system Avango [Tra99] and Lightning [Bla98]. Both are cluster aware and support an arbitrary amount of different views.

Figure 3: Hardware prototype: Customized glasses, filter adapter and projector stand.

3. Related Work

Recently we have seen improvements in the field of shutter and projector technology, but there are still only a few attempts to provide multiple users with individual perspectively correct stereoscopic images. The two-user Responsive Workbench [Agr97] displays four different images in sequence on a CRT-projector at 144Hz, which results in 36Hz per eye per user. They also developed custom shutter glasses for cycling between four eyes. At these low frequencies, there flicker is unavoidable and cross talk of CRT projectors is very apparent. Blom et al. [Blo02] extended this approach to support multi-screen environments such as the CAVE [Cru93], but still suffers from the same problems. Barco [Bar04] developed the "Virtual Surgery Table", which provides two users with individual stereoscopic images by combining shuttered and polarized stereo into one system. Our work is an extension of this approach. Recently Bolas [Bol04] provides an overview of different multi-viewer setups. Preliminary Work of the authors has been described in [Fro05].

4. Summary

We have successfully implemented a working prototype for two users. We have not fully evaluated the setup but there are already some advantages and disadvantages visible:

- Combining polarization and shuttering doubles the brightness compared to a shutter only approach, since each user is exposed to an image for twice the time.
- Optimized optical filter combinations increase the brightness
- Circular polarization is simple to add
- Cross talk through the projector shutters and the shutter glasses
- Cross talk because of imperfection of the polarization elements
- Heat is developed on the projector shutter elements, if they are small and very close to the projector.

5. Future Work

We are already in the process of extending the system to support four users. Besides the technical challenges, one of the most interesting research directions is the development of interaction paradigms for multiple users in these local environments.

The general question remains: How scalable is the approach? What is maximum number of users which can be supported? We are quite optimistic to be able to extend the system to up to four users. Beyond this limit, the main limitation is the remaining brightness per user and the crosstalk of the projector shutters. Here mechanical shutter approaches might be a solution.

References

[Agr97] Agrawala M. et al..: The Two-User Responsive Workbench: Support for Collaboration Through Individual Views of a Shared Space, Computer Graphics (SIGGRAPH '97 Proceedings), volume 31, pp. 327–332, 1997.

[Bar04] Barco: Virtual Surgery Table. http://www.barco.com/VirtualReality/en/products/

[Bla98] Blach R. et al, A Flexible Prototyping Tool for 3D Real-Time User-Interaction. Proceedings of the Eurographics Workshop on Virtual Environments 98 , 1998 pp. 195-203

[Blo02] Blom K., Lindahl G., Cruz-Neira C.: Multiple Active Viewers in Projection-Based Immersive Environments. Immersive Projection TechnologyWorkshop, March 2002

[Bol04] Bolas M, McDowall I, Corr D

New Research and Explorations into Multiuser Immersive Display Systems, IEEE Computer Graphics & Applications Jan/Feb 2004 pp18-21

[Cru93] Cruz-Neira, C., Sandin, D.J., and DeFanti, T.A. Surround-screen Projection-based Virtual Reality: The Design and Implementation of the CAVE. Proceedings of SIGGRAPH '93, 135-142, 1993.

[Fro05] Fröhlich B. et al., Implementing Multi-Viewer Stereo Display. Proceedings of WSCG 2005 in Plzen, 2005

[Tra99] Tramberend, H. Avocado: A Distributed Virtual Reality Framework. Proceedings of VR'99 Conference, Houston, Texas, 14-21, March 1999.