CALVIN: an Immersimedia Design Environment Utilizing Heterogeneous Perspectives

Jason Leigh, Andrew E. Johnson
Electronic Visualization Laboratory (EVL), University of Illinois at Chicago
(jleigh@eecs.uic.edu)

Abstract

In this paper we describe CALVIN, an immersive multimedia approach to applying virtual reality in architectural design and collaborative visualization emphasizing heterogeneous perspectives. These perspectives, including multiple mental models as well as multiple visual viewpoints, allow virtual reality to be applied in the earlier, more creative, phases of design, rather than just as a walk-through of the finished space. CALVIN's interface employs visual, gestural, and vocal input to give the user greater control over the virtual environment. A prototype of CALVIN has been created and used in the CAVE(tm) virtual reality theatre.

1 Introduction

As multimedia systems evolve beyond the two-dimensional desktop they will allow users to engage in richer interaction with multimedia information. Virtual reality (VR) can provide a medium for this interaction allowing users to experience an immersive multimedia (or immersimedia) environment.

Traditionally the raison d'etre for immersive applications in general, and VR in particular, has been three dimensional architectural walk-throughs. This limits VR to the final stage of the architectural design process, where a CAD model can be displayed in a VR environment. Our surveys suggest that this final stage, involving the building of the CAD model, only occupies about 20% of the design time. The remaining time is spent iterating over many experimental designs - a process which is largely unsupported by computers.

We believe VR can be successfully applied to the earlier stages of design. An important component of such a design system is the ability to see information from heterogeneous perspectives, including not only those from multiple physical viewpoints, but those from multiple mental models. To further investigate this, we have created CALVIN (Collaborative Architectural Layout Via Immersive Navigation) a networked virtual design space embodying some of these concepts.

In the following sections we will describe these ideas in greater detail. We will then describe CALVIN and give an example of its use.

2 The Design Process

This concept of applying heterogeneous perspectives to a design environment was motivated by two informal surveys conducted on veteran architects and architecture students. Our findings are summarized below.

The greatest amount of time is spent iterating over sketching and model building, before finally committing the design to CAD. The CAD phase is considered the least creative and most tedious phase of design, but is described as the most obvious phase to apply VR as a way to *impress* clients through VR walk-throughs.

Collaboration is a crucial part of the design process. Architects spend approximately equal amounts of time in informal meetings with colleagues, as they do in formal scheduled meetings with colleagues, clients, and engineers. More work is done in informal collaboration, where the emphasis is on the exploration of ideas, compared to formal collaboration, which mostly consists of confirming designs brought to the meetings.

3 Multiple Perspectives in Design

One of the obvious affordances of VR is its ability to depict environments from an ego-centric perspective, where participants are immersed in the environment. This has been leveraged by many researchers to produce 3D walk-throughs of architectural spaces. These implementations have been successful because they offer clients the ability to tour a building design before it is built. However this is only one of several perspectives that can be applied to the design process. These perspectives include those from:

1. multiple camera parameters.
2. multiple specific information filters.
3. multiple collaborators offering their opinions.
4. experimenting with multiple designs.
5. design ideas maturing over time.

The following subsections will elaborate further on these perspectives.

3.1 Multiple Camera Parameters

Although the single ego-centric perspective is useful in the evaluation of a pre-designed space, it may not be the most appropriate perspective for the actual design process. An exo-centric perspective, as though looking at a miniature model, may be better for maintaining a global sense of the space. This alternative perspective has already been applied by many researchers[11] with considerable success.

We call this notion of providing two perspectives "mortals and deities." In the most trivial case mortals view the world from an ego-centric perspective and deities view the world from an exo-centric perspective. Figure 1 shows a mortal and a deity in a virtual design environment where the mortal is standing within the environment and the deity is towering over it. Deities may assume more influential roles over mortals. That is, participants may have heterogeneous roles in the environment.

3.2 Multiple Information Filters

Although multiple camera perspectives have already been applied to VR in architecture, little has been done to generalize this notion in collaborative environments.

Olson[8] asserts that multiple representations are important in a collaborative work environment. Similar work in visual filtering has been done by Laurel[5] and Bier[1], however neither explores the interaction between the participants in a collaborative environment.

The default assumption in most collaborative virtual environments is that participants experience a homogeneous world. That is, the world's visual and aural properties are identically perceived for all participants. Providing heterogeneous perspectives over the same model allows each participant to apply his or her expertise by supplying the visual representations each is accustomed to interpreting.

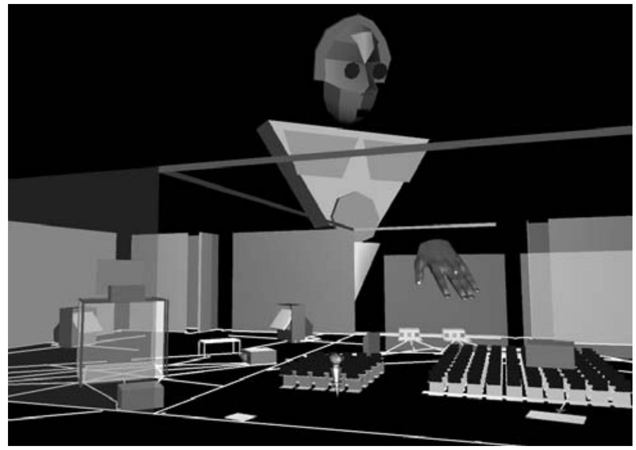

Figure 1. A Mortal and Deity Collaborate in a Shared Virtual Design Environment

3.3 Multiple Opinions via Collaboration

An important part of collaboration for architects is the alternative perspectives gained by eliciting feedback from their colleagues, clients, and engineers. In the context of mortals and deities, the roles collaborators assume as mortals and deities can dictate the actions they are capable of exercising. For example, mortals can more easily perform fine manipulation while deities can more easily perform gross manipulation. Mortals and deities may assume the roles of apprentices and teachers[4], or clients and demonstrators.

3.4 Experimenting with Multiple Designs

As VR is so well suited to solving problems in architecture, it is ironic that it is being used to support the least creative part of the process. VR can be introduced earlier in the design process through two means. Firstly, a collection of interior objects can be provided for the users to plug into the environment. Secondly a three dimensional sketching interface will allow designers to quickly turn their hand-drawn sketches into rough three dimensional studies. These rough studies can then become additional pre-defined objects which can be placed in the scene.

3.5 Maturing Design Ideas over Time

Finally we wish to incorporate the notion of time in the design environment. That is, the virtual environment still persists after the participants leave. At a later time, a participant may re-enter the space to do more work, encouraging informal collaborations. Since creativity does not follow a schedule we believe that a collaborative environment requiring apriori scheduling would be too limiting.

4 CALVIN

CALVIN [6, 7] is a prototype system that applies our ideas of providing heterogeneous perspectives for collaborative design. Currently CALVIN implements only a subset of these concepts. Specifically CALVIN implements multiple camera perspectives and allows multiple participants at several remote locations to collaboratively design in a shared architectural space. We will begin by describing the individual components of CALVIN, and then discuss a sample application.

4.1 Hardware and Software

CALVIN was designed to run in the CAVE [3] virtual environment. The CAVE is a 10 foot by 10 foot by 10 foot room constructed of translucent walls that are rear-projected with stereoscopic images. A participant dons a pair of LCD shutter glasses to mediate the imagery. A magnetic tracker, attached to the glasses, relays the position and orientation of the user's head to the computer. A wand, with 3-buttons and a joystick, and equipped with a magnetic tracker, is provided to allow interaction with the virtual environment.

The core of CALVIN is the CAVE library, providing the routines to drive several different VR hardware platforms. CALVIN itself is written in C++ using OpenInventor(tm) as the underlying graphics library.

4.2 Avatars in CALVIN

We establish co-presence in the virtual space by representing each user as an avatar. These avatars consist of a separate head, body, and hand, allowing the environment to transmit gestures between the participants. These avatars provide significantly contrasting representations, and give sufficient cues to discern the direction the avatar is facing. Thus, participants may communicate notions of relative position with phrases such as "it is to your left."

4.3 System Design

CALVIN allows multiple networked participants to work in the same virtual space. Multiple distributed CALVINs running on separate VR systems are connected via a centralized database that guarantees consistency. Many similar approaches have been implemented by other researchers [2, 9, 10, 13]. Although a centralized database can be a bottleneck as the number of users grows, we use this simple approach because it allows us to concentrate on the human-factors issues of collaboration. A conference-phone system is used to relay voice between the various sites. We are currently testing live video within CALVIN to facilitate face-to-face communication and support negotiation tasks.

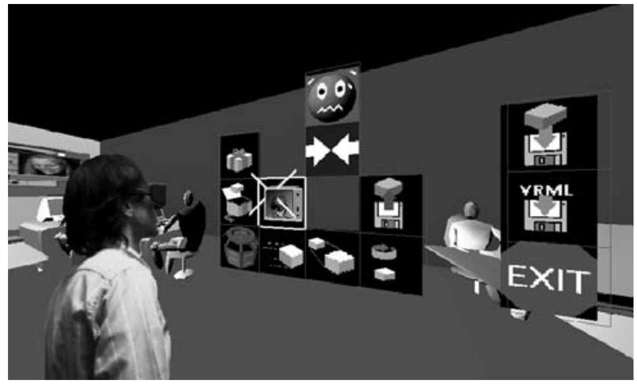

Figure 2. The Virtual Visor

4.4 User Interaction

CALVIN uses two complementary interfaces: the Virtual Visor and speech recognition. The Virtual Visor simulates a head-up display (HUD) [12] in the virtual environment. The visor can be used as an input device controlled using the user's head orientation as shown in figure 2. To make a selection the user looks at the appropriate menu option and presses a button on the wand. Speech recognition is currently provided by a commercially available, speaker-independent software package. This allows the user to replace the visor's menu with voice commands. Audio feedback is used to confirm menu selections and mode changes.

As CALVIN is started, each user is dropped into the shared design environment. The user can walk within the confines of the CAVE and the user can move the CAVE through the virtual space. CALVIN monitors the position of the user in the virtual space and adjusts the vertical position of the scene accordingly, allowing the user to walk over the landscape. The user selects a manipulation mode (move, scale, rotate, etc.) using the Virtual Visor or the speech recognition system; the wand is then used to select and manipulate objects in the scene.

4.5 Application of CALVIN to Design

CALVIN was used to help design the floor layout of equipment in the GII Testbed rooms at Supercomputing '95 in San Diego, which included a CAVE, two Immersadesks(tm), two video walls, and seating for 200 people. CALVIN allowed our personnel to give their feedback on the design of a room several thousand miles away, and several months away from construction. It also allowed us to train our on-site personnel here in Chicago before they left for San Diego.

A CAD model of the room was converted and loaded into CALVIN along with existing models of the equipment. For testing purposes CALVIN was run in a CAVE, and on an Immersadesk. The deity, on the Immersadesk, first organized the equipment in a preliminary configuration. Members of our lab responsible for the room layout stood in the CAVE taking the mortal's role. They evaluated visibility, accessibility, and general usability. The CAVE was well suited to this task since users could see their own bodies in relation to the virtual objects.

Others stood around the Immersadesk taking the deity's role and evaluating the scene from above. They were concerned about traffic patterns, waiting areas, and interference between pieces of equipment. The mortal and deity tried out various configurations of the room until all the requirements were satisfied in the design shown in figure 1.

5 Conclusions and Future Work

CALVIN allowed us to experiment with numerous architectural designs, and quickly modify them, converging to a final design. The people participating in this design session felt that CALVIN was a valuable tool, not only in its ability to construct the space but also in the way it encouraged several users to actively participate in the designing of the space.

We believe this approach can be generalized to other disciplines such as collaborative engineering and scientific visualization which typically involve multi-dimensional data. However, participants operating on different views may cause more confusion than insight. An appropriate interface must allow participants to share views and more importantly, mental models. Our current work is focused on isolating the parameters that will successfully allow this form of collaboration.

Acknowledgements

We would like to thank those who generously shared their views in our surveys; and in particular Michael Kelley, Bruce Gibeson and Steve Grinavic at University of Southern California.

This research is partially supported by NSF grant CDA-9303433 which includes support from ARPA.

References

[1] E. A. Bier, M. C. Stone, K. Pier, W. Buxton, and T. DeRose. Toolglass and Magic Lenses: The see-through interface. In J. T. Kajiya, editor, *Computer Graphics (SIGGRAPH '93 Proceedings)*, volume 27, pages 73–80, Aug. 1993.

[2] C. Carlsson and O. Hagsand. DIVE - a multi-user virtual reality system. In *Proceedings of the IEEE Virtual Reality Annual International Symposium*, 1993.

[3] C. Cruz-Neira, D. J. Sandin, and T. A. DeFanti. Surround-screen projection-based virtual reality: The design and implementation of the CAVE. In J. T. Kajiya, editor, *Computer Graphics (SIGGRAPH '93 Proceedings)*, volume 27, pages 135–142, Aug. 1993.

[4] L. Kjelldahl and J. Lundequist. Computer aided architectural design work. In H. J. Bullinger and B. Shackel, editors, *Human-Computer Interaction - INTERACT'87*, pages 1097–1100, 1987.

[5] B. Laurel and R. Strickland. Placeholder: Landscape and narrative in virtual environments. In *Multimedia'94*, pages 121–132, Oct. 1994.

[6] J. Leigh, A. E. Johnson, T. A. DeFanti, and M. Kelley. Transcontinental collaborative design in a shared virtual environment. demonstration in the CAVE at the Supercomputing '95 Conference, Dec. 1995.

[7] J. Leigh, A. E. Johnson, C. A. Vasilakis, and T. A. DeFanti. Multi-perspective collaborative design in persistent networked virtual environments. In *Proceedings of IEEE Virtual Reality Annual International Symposium '96*, Apr. 1996.

[8] J. S. Olson, L. A. Mack, and P. Wellner. Concurrent editing: The groups interface. In D. Diaper, editor, *Human-Computer Interaction - INTERACT'90*, pages 835–840, 1990.

[9] C. Shaw, J. Liang, M. Green, and Y. Sun. The Decoupled Simulation Model for Virtual Reality Systems. In *Proceedings of CHI '92*, pages 321–328. ACM, May 1992.

[10] G. Singh, L. Serra, W. Ping, and H. Ng. BrickNet: A software toolkit for network-based virtual worlds. *Presence: Teleoperators and Virtual Environments*, 3(1):19–34, 1994.

[11] R. Stoakley, M. J. Conway, and R. Pausch. Virtual reality on a WIM: Interactive worlds in miniature. In *SIGCHI '95 Proceedings*, pages 265–272, May 1995.

[12] C. D. Wickens and L. J. Long. Conformal symbology, attention shifts, and the head-up display. In *Proceedings of the Human Factors and Ergonomics Society*, pages 6–10, Oct. 1994.

[13] M. J. Zyda, D. R. Pratt, J. G. Monahan, and K. P. Wilson. NPSNET: Constructing a 3D virtual world. In *Proceedings of the 1992 Symposium on Interative 3D Graphics*, pages 147–156, 1992.