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The LAIR: Lightweight Affordable Immersion Room

Abstract

This paper proposes a virtual environment system called a lightweight affordable immersion room (LAIR) that we propose for use in space and financially constrained situations. The LAIR consists of four walls arranged in a square providing a 360° degree view. By using front projection and two projectors per wall, the LAIR provides a compact environment which gives users some freedom of movement. The LAIR may be considered in terms of performance and cost as somewhere between a power wall and a CAVE—more immersive than a power wall, but less than a CAVE—and similarly moderate in terms of use of space and cost.

1 Introduction

A CAVE (Cruz-Neira, Sandin, & DeFanti, 1993) is an immersive virtual reality projection device useful in a wide variety of applications. It realizes immersion by displaying a surrounding wide-angle field of view, essentially that achieved in physical reality. The typically four to six screens are back projected to prevent users from occluding the images. However, significant space is required to accommodate the projectors and their required throw distances.

In cases where the space is not available a power wall may be considered (Steinwand, Davis, & Weeks, 2002 is an example). This consists of one or more screens arranged linearly along a single wall. Because the field of view is not surrounding, the same degree of immersion cannot be achieved.

In this article another system is proposed, the lightweight affordable immersion room (LAIR). This system is front projected, provides some of the features of a CAVE, and does not require as much space as a CAVE. The LAIR consists of four walls arranged in a square providing a 360° view as shown in Figure 1.

2 Previous Work

A CAVE provides users with an immersive 3D virtual environment by surrounding their field of view with projected imagery. The layout of the screens determines how much of the field of view will be covered. The original CAVE (Cruz-Neira et al., 1993) uses a four screen layout of front, right, left, and bottom screens providing coverage of most of the field of view. Some variations on this eliminate one or more screens (Gross et al., 2003) and lose some coverage of the field of view. Other layouts, such as that of a dome (Gaitatzes, Papaioannou, Christopoulos, & Zyba, 2006) can be used.

Should resources and space be limited, a power wall may be used (Belleman, Stolk, & Vries, 2001; Steinwand et al., 2002). A power wall consists of one or more screens arranged linearly along a single wall. Be-

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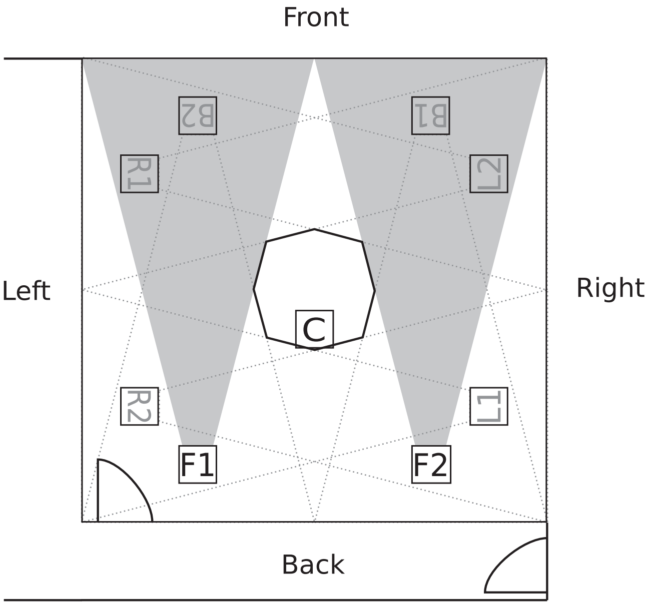

Figure 1. *Projector layout: A user standing in the central octagonal region will not cast shadows on the walls. F1 and F2 are the projectors for the front wall. C is the central projector to be used as an information display.*

cause of this, they only cover a small portion of the field of view.

3 LAIR

The LAIR is a virtual environment consisting of four walls arranged in a wrap-around square. This provides a 360° view for users. Through a different approach to front projection it creates an environment where users have some space in which they can move without occluding the projected imagery.

3.1 Projection

The LAIR system uses front projection and thus requires significantly less space than a back projected system. However, it minimizes the disadvantages of front projection by arranging the projectors in such a way that shadows of the user are not cast, and a user can even move around within a small area. This is shown in Figure 1.

As can be seen in Figure 1, two projectors are used which are offset from the center of the wall to cover the area of a screen. Due to this offset a user can stand in the center between the two projectors without casting a shadow. By repeating this offset pattern for all four screens, the intersection of all eight projection volumes produces an octagonal region in the center of the LAIR in which a user can stand without casting a shadow on any of the screens. This *occlusion free region* is depicted by the octagon in Figure 1. A side effect of using two projectors per wall is the reduced throw distance required by each projector and thus the LAIR can be compacted into a relatively small space, in this case a 3.5 m^2 room. The reduction in throw distance also enables the use of cheaper projectors.

Using two projectors per wall produces projector matching and blending issues. Although blending and matching is possible it requires extra equipment, and costs more. For these reasons the projectors are manually calibrated, although better results could be obtained using automatic calibration tools.

The ninth and central projector has a mirror attached to reflect the image downward for use as an information display.

3.2 Heat and Computation Power

With the environment enclosed on all four sides, heat is an issue. Air conditioning was installed in the ceiling to introduce air recycling. This prevents projectors from overheating and the user from becoming uncomfortable.

The particular LAIR described was driven by a single workstation (Dell Precision 690). Using Matrox DualHead2Go boxes it is possible to connect all eight main projectors to a four port video card like an Nvidia Quadro X2.

4 Conclusion

The LAIR offers some of the functionalities of a CAVE, for example, supporting a full 360° view. Using a throw distance of approximately 3 m, the projectors cover 64% of each wall. The LAIR offers active stereoscopic vision via LCD shutter glasses; it supports user movement albeit significantly restricted to the occlusion free region and it facilitates head tracking and user interaction in a fashion akin to those used within a CAVE. The particular LAIR that we have built cost under € 45,000 and consumes 3.5 m × 3.5 m of space and is 2.5 m high.

Acknowledgments

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