Affordable Immersion Revisited – A Proposal for a Simple Immersive Visualization Environment (SIVE-Lab)

Mark LINDQUIST

1 Introduction

Immersive visualization techniques for design decision making have been available to spatial design practitioners, planners and educators for nearly two decades. Resources employed often include large-scale projection based facilities that provide quasi-realistic digital visualizations coupled with dynamic interaction opportunities with proposed building and landscape designs over space and time. While previously too expensive for many public entities and firms, the affordability has reached the point that immersive systems should be moving out of specialized academic settings and into the real world. However, the current situation seems to be the contrary; such facilities and processes remain novel in many academic and professional settings alike. The drawbacks to the lack of uptake of immersive design processes are numerous. It has been presented that immersive visualization has the capacity to communicate complex spatial proposals to a broader range of participants in the design and evaluation process than media conventionally employed by designers (DANAHY, 2001). LANGE (2005) asserts that many of the problems contributing to unsuccessful design collaboration, particularly between professionals and the public, can be attributed to a communication breakdown between those involved, which visualizations can aid in overcoming. This paper argues that affordable tools and techniques exist for immersive visualization to be more widely used, which can potentially reduce confusion and derive greater consensus in design and evaluation processes, leading to a more socially sustainable designed environment.

2 Immersive Visualization

Immersive visualization, a combination of hardware and software which allows a viewer to experience looking around and moving about in virtual space, has been used by planners and landscape architects for a generation and is becoming technologically robust. Immersion in this case has been defined as the “degree of visual simulation a virtual reality interface provides for the viewer – the degree of the suspension of disbelief” (CRUZ-NEIRA ET AL., 1992). The success of immersive visualization over conventional media for conveying landscape experience has been presented by DANAHY (2001). Immersive visualization is beneficial to the design process as participants are in a better position to interact with and evaluate a proposal than when compared to conventional design techniques such as drawing. Immersive visualization approaches have proven to be especially beneficial for collaboration involving those untrained in spatial design disciplines by BISHOP (2005) and KWARTLER (2005).
3 Immersive Environments

Immersive environments use many configurations. Systems can be as simple as one widescreen (16x9 aspect ratio) monitor on a desktop for a single user connected to a consumer level PC. For multiple users projection based facilities are more appropriate (BISHOP ET AL., 2001). Projection based facilities can offer visualizations that are closer to a realistic scale for the observer, facilitating communication to, and engagement of, more people at once, closer to realistic experience. Multiple screens, from two to as many as twelve, can be employed to provide a more immersive experience by engaging more of the human visual system. The Cave Automatic Virtual Environment (CAVE) uses 5 screens (3 walls, a ceiling and a floor) to immerse a viewer (CRUZ-NEIRA ET AL., 1992). Stereoscopic imagery and/or head mounted displays have also been used, although for spatial design usually do not engage peripheral vision as well as large projection based facilities.

Visualization hardware has evolved and become ever more affordable significantly over the years. One of the first pieces of hardware that made visualization accessible to those without access to a true mainframe supercomputer was the Silicon Graphics 4D/240GTX superworkstation (AKELEY, 1989). While moving out of the realm of supercomputers brought the price down, these specialist graphics units ran into the hundreds of thousands of dollars range. By the late 1990’s specialist hardware was being surpassed by high-end consumer hardware being driven by the commodity gaming industry. As of writing consumer grade graphics cards have now far surpassed the graphic capabilities of dedicated graphic workstations for driving 3d and 4d visualizations. This development has brought digital visualization in general and immersive visualization in particular to an affordable range and should result in more widespread use. To date there has not been the implementation of immersive environments that could be expected owing to real and perceived barriers.

4 Barriers to Uptake

There are a variety of reasons that have been cited contributing to a lack of uptake of digital visualization and immersive visualization for design and planning. In general terms LANGE and BISHOP (2005) attribute the lack of integration of digital visualization in the planning process to the absence of easy to use software tools, insufficient connection of visualizations to data for decision-making, and the difficulty of manipulating visualizations in real-time. Over a decade ago DORTA and LALANDE (1998) cited the perceived complexity and cost of immersive tools, and time commitment involved in using the tools, as a significant reason for their limited use. The combinations of cost and requirement of specialist knowledge have been the main barriers to uptake of immersive visualization in landscape architecture and planning. Affordable immersive systems have been presented recently that run in excess of $25 000 (PETROVICH, 2004), far outside the budget of many professional offices, government departments or academic units. Immersive environments have been created for architecture, landscape architecture and planning that utilize commodity hardware and software (ie. a PC running Windows) in an attempt to promote wider use (KALISPERIS ET AL., 2002). One major drawback is that the system still relied on
specialist knowledge in the setup stage, requiring Java programming and advanced hardware knowledge to setup and maintains the physical environment. Even more affordable, a working immersive system was built for under $1400 (USD) over 5 years ago (CLIBURN, 2004). While this system did overcome barriers of cost, its creation still relied upon an unreasonable level of specialist understanding of computer programming.

Technology has now evolved to the point anybody who can connect a monitor to a computer can build their own immersive environment using commodity hardware and software, which is proposed in this paper to be the state of the art. State of the art is sometimes misconstrued as development that is technologically more advanced than it previously was. Webster defines ‘state of the art’ as “the level of development (as of a device, procedure, process, technique, or science) reached at any particular time usually as a result of modern methods” (“state of the art,” 2010). This paper argues that the state of the art for immersive spatial design environments creates affordable, replicable systems that can be adopted en masse, thus emphasizing the outcome or the technique rather than the tool. Creating immersive environments with an ample budget and technical expertise has proven to work, yet to date is untenable for the variety of users in practice, academia or government as demonstrated by the lack of uptake. This paper presents a case study of an affordable immersive visualization environment, built with consumer grade hardware and software that required very little specialist knowledge to create.

5 Case study: Simple Immersive Visualization Environment

5.1 Hardware and Software

The Simple Immersive Visualization Environment (SIVE-Lab) is a mono immersive system and was designed with and employed commodity hardware and software for a total cost of just under $5000 (USD). The breakdown of costs is listed in table 1.

Tab. 1: Immersive Environments Lab Cost Breakdown

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost (USD)</th>
<th>Quantity</th>
<th>Total (USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AlienWare Area-51 750i Desktop PC</td>
<td>$1,961.68</td>
<td>1</td>
<td>$1,961.68</td>
</tr>
<tr>
<td>Dell 1609WX Projectors</td>
<td>$730.00</td>
<td>3</td>
<td>$2,190.00</td>
</tr>
<tr>
<td>Matrox TripleHead2Go Digital</td>
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<td>1</td>
<td>$305.90</td>
</tr>
<tr>
<td>Screen Wood and Paint</td>
<td>$126.40</td>
<td>1</td>
<td>$126.40</td>
</tr>
<tr>
<td>Miscellaneous Cables</td>
<td>$144.30</td>
<td></td>
<td>$144.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total (USD) $4,728.28</td>
</tr>
</tbody>
</table>
The critical hardware component that made the SIVE-Lab feasible was a $300 USD Matrox Triplehead2Go (MATROX, 2010), a device aimed at the gaming community enabling the connection of three monitors to one PC. The TripleHead2Go runs off of the PC video card, splitting and syncing a video signal across three screens. Aimed primarily at desktop users with multiple monitors, the device works equally well with a projection based system. Three 8’ × 5’ screens were fabricated out of plywood in the department woodshop, hung on the wall and painted which resulted in a total screen size of 24’ wide × 5’ tall (7.32 metres × 1.52 metres). Projectors were Wide Extended Graphics Array (WXGA) resolution, providing 1280 × 800 pixels each or a total projected resolution of 3840 wide × 800 pixels tall. Projectors were initially placed on tables and eventually mounted on the ceiling to free up seating space in the lab. The completed SIVE-Lab can seat 10 for immersive experiences and up to 25 for viewing regular presentations (Fig. 1). The consumer-grade PC runs Windows 7 Professional 64 bit with an Intel® Core™2 Duo Desktop Processor E8400 @ 3.00 GHz, 8 GB RAM and an Nvidia GeForce GTX 295 video card. At the time of writing installed software included: Adobe CS3 Suite (Acrobat, Illustrator, InDesign, Photoshop); Autodesk Map 3d; Autodesk 3ds Max; and Sketchup Pro 7.

5.2 Workflows

The SIVE-Lab was used in landscape architecture and urban design studio courses with 2nd year and 4th year undergraduate landscape architecture students. Second year students were engaged in a 4 week site design project for an urban streetscape or plaza. Fourth year students were engaged in a semester long urban design project. Students were provided the pixel dimensions required for images, video and renderings to span three screens. Students were afforded 24 hour access to the lab, enabling the use of the SIVE-Lab for design investigation and experimentation throughout the design process, rather than merely for large scale projection for presentation of completed designs.

![Fig. 1: Simple Immersive Visualization Environment Lab (SIVE-Lab)](image)
For the initial exercise there was no expressed methodology dictated to the students. In this instance two workflow patterns emerged:

1. The majority of 2nd and 4th year students designed on a single computer screen at their desk, then immersively evaluated a design when the SIVE-Lab was available. After anywhere from 15 minutes to 1 hour in the SIVE they would return to their own laptops to continue.
2. In two separate instances individual 4th year students used the SIVE-Lab with 3d modelling software to interactively and dynamically model and evaluate a design iteratively. These sessions lasted a minimum of four hours and up to 10 hours.

6 Discussion

6.1 Opportunities and Constraints

The study used qualitative observation methods and follow-up interviews of second year and fourth year undergraduate students within the conventional design studio and SIVE-Lab. The SIVE-Lab offers many advantages over preceding immersive environments and overcomes many of their barriers to uptake. The cost of the SIVE-Lab is such that it is comparable to purchasing three consumer-grade desktop personal computers. In terms of implementation the entire lab was conceived and built by a faculty member with the help of one person to hang the screens. The cost may have increased by a few hundred dollars had dedicated screens been purchased, which would still not be cost prohibitive. The entire system runs a consumer grade operating system (Windows 7), and therefore can run any software designed for the Windows environment, with the benefit of spanning three screens for immersion. The system provides the additional benefit of working non-immersively across the large display, enabling the efficient use of multiple windows, which has proven to increase productivity when compared to using smaller screens (CZERWINSKI ET AL., 2006). Students responded positively to both designing and presenting in the SIVE-Lab. The benefits of a consumer grade system meant that students did not need to learn any new software; it was a matter of reformatting dimensions to use the immersive media to suit their needs be it for designing, evaluating or presenting. Users added webcams for video chat through Skype, installed extensions to Sketchup for terrain manipulation and other advanced modelling processes. The versatility and relative ease of use of consumer-grade hardware and software in this instance far outweighed any negative aspects, and would encourage widespread uptake. In addition, a major benefit of the SIVE-Lab is that using the Matrox hardware any laptop could be connected to the system and, provided the video card was adequate, be used with all the users own software settings and extensions.

One constraint that emerged during the study was access to the SIVE-Lab. 45 students competed for access, and while 24-hour provisions helped there was limited ‘design time’ in the SIVE-Lab. Emerging from this was the hypothesis that this scenario would likely play out if such a system was introduced in a professional environment. To combat issues of access, students often designed on their personal computer using a standard laptop screen or monitor and formatted still images and animations to the widescreen dimensions of the screen in the SIVE-Lab. There were observed benefits to incorporating even a small amount of time in the SIVE-Lab, which were corroborated by qualitative responses from
students. These sessions were more for personal design evaluation than real-time designing. This is very promising as educating future designers of their own perceptual limitations, encouraging a more objective evaluation of their proposals, and emphasizing that others’ objective evaluations are valid has the opportunity to produce more responsive and sensitive designers. The knowledge discovery that students experienced through objective experiential evaluation of their proposals would have been very unlikely relying on conventional tools and techniques. What requires further evaluation is whether it was the immersive qualities that enhanced knowledge discovery by the students, or if it could be attributed to a larger screen that allowed a student a different perspective on their work.

6.2 Immersive vs non-immersive tasks

The study observed that all aspects of the design process covered by the studio projects in this instance benefitted from immersive exploration. However, given issues of limited access to the SIVE-Lab it is pertinent to ascertain areas of the design process that would most benefit from immersive visualization. This is especially true if it would be adopted in professional settings. What emerged from the study was that beginning and advanced students alike benefitted from the large screen size and immersive interaction with their proposed environments, be they 2d or 3d visualizations. Two advanced students experienced with manipulating and designing in 3d software programs (Sketchup and 3ds Max) benefitted from dynamic interactive modelling at the design concept stage; second year students that were less experienced in both design and digital media benefitted from creating 2d panoramic montages in Photoshop, and evaluating the spatial implications immersively after creating them. Students reported that the SIVE-Lab offered a better sense of spatial experience than when compared to viewing on their laptops or printing/plotting their imagery. The other major benefit was during design presentation. While not all students presented fully immersive imagery, all benefited from having three screens at their disposal. Based on observing presentation feedback, those students presenting immersive montages, animations and real-time models were able to more effectively communicate their proposals to outside critics.

7 Future Directions

One argument of this paper is that the lack of widespread uptake of immersive design and evaluation processes can be overcome by emphasizing student experimentation with immersive technologies and providing ease of access to said technologies for professionals. To support widespread uptake future research will need to investigate the impact and uptake of immersive design processes in professional and academic settings. In addition, the current focus of this research is on simple immersive environments and has not studied the impact of other increasingly affordable technologies, ie. stereo vision or tangible interfaces. The advances made in gaming hardware have significantly impacted the affordability and ease of building of immersive environments. It seems inevitable that the push by Hollywood and television makers for 3d capable televisions promises to eventually lower prices for consumers and in turn can be adopted affordably for other uses, including spatial design and evaluation.
A promising area for future research that is currently being explored by the author is the potential of augmenting visual virtual landscapes with sound. Interest by government and policymakers is increasing in this area, particularly in the regulation and abatement of sound in the form of environmental noise from road traffic, aircraft, railway and machinery and that impact on health and safety (Directive 2002/49/EC). Purely visual approaches to landscape experience have been criticized, citing the complex multi-sensory appreciation of individuals at differing socioeconomic levels (SCOTT ET AL., 2009) and the important impact of sound on the perception of outdoor environments (ANDERSON ET AL., 1983). Early experiments by the author indicate that incorporating sound into virtual reality simulations of urban landscapes can provide an increased sense of being there, or presence, with the potential to communicate to a broader audience providing a more accurate psychological response to a landscape.

8 Conclusion

Affordable tools and techniques exist for immersive visualization to be more widely used in the design and design evaluation process. Historically immersive environments relied on a specialist hardware and software and as a result were beyond the scope of most offices and government bodies. Some problems contributing to unsuccessful design collaboration can be overcome using immersive visualization and can engage a broader range of participants in the design and evaluation process. Immersive environments have reached a tipping point of affordability and usability, able to be implemented for under $5000 without the need for specialist skills or knowledge, which can increase their uptake by designers and administrators. Immersive environments can convey the experience of being in a place, which can contribute to a better understanding of spatial design proposals for designer and client alike. Widespread uptake of immersive environments can expand participation in the design process and ultimately lead to better designed environments.

References


