MULTIMODAL VIRTUAL REALITY ENVIRONMENT FOR ARCHITECTURAL DESIGN (RE)PRESENTATION

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Abstract. The diversity of representations and the complexity of capturing and communicating the design process and its rationale present a challenge to architects. This paper proposes a multimodal virtual reality environment (MVE) aimed at utilizing the inherent advantages of distinct media, as opposed to a stand-alone virtual reality environment. Virtual reality is seen here as one of the tools in the larger milieu of interactive multimedia tools available to architects. The theoretical framework underlying its development explores the role of digital tools in the design process, their adaptability to existing workflow and issues of representation and perception, especially how design ideas are represented, evaluated and manipulated in the mind. The development of MVE followed a cycle of design, usability studies by a focus group and redesign.

1. Introduction – The challenge for a digital architectural presentation

1.1. THE ARCHITECTURAL DESIGN PROCESS AND THE ROLE OF CRITIQUE

Architectural design can be thought of as an iterative visual process involving representations. Chandrasekharan (1990; 1999) suggests that design is

essentially a recursive 'propose-critique-modify' process. Though others refer to the same process by different names, there appears to be broad agreement on this model of design process. Critique primarily involves analysis of the causes of design failure (Chandrasekharan, 1990) and therefore requires an understanding of the behavior of the proposed design solution. The critique process is at the heart of the design studio, which forms the core of architectural education.

1.2. CHALLENGES FOR CRITIQUE USING DIGITAL ENVIRONMENT AND THE CASE FOR A MULTIMODAL ENVIRONMENT

Despite the widespread utilization of computers in design studios, the project review process still relies heavily on printed media. One reason for this is that architectural design representation is inherently multimodal in nature, as revealed in the traditional "pin-up" review. Here, the design presentation involves displaying a variety of media and modalities, including a collection of drawings: plans, sections, elevations, perspectives and axonometrics, site photographs, massing models, detailed models of interiors and, sometimes, working models of an exciting detail. Each of these modalities is ideally suited to reveal a particular aspect of the design. Simultaneous display of representations in multiple modalities facilitates easy cross-referencing, helping critics to see new connections. In computer-based presentations, particularly those using PowerPoint, simultaneous display is often replaced by a sequential presentation. The emphasis is thus shifted from an analytical and analogical perspective making the reflection process more difficult. Large screen virtual reality displays have the potential to overcome this limitation caused by limited screen size.

1.3. PSYCHOLOGICAL ASPECTS OF DESIGN THINKING

While attempting to create a medium for architectural representation, it is important to look at the behavior of the human mind during the creative process. Takala (1993, p. 93) defines creativity as the "forming of new patterns from previously existing patterns in the human mind". Design is not linear problem solving with a definite starting point. In fact, the designer's focus of attention shifts between different aspects of the design problem. Takala (1993) refers to the focus of attention as a 'view', and each 'view' is evaluated for discrepancy. The design process ends when a number of different 'views' can be taken without discrepancy. The distinction between general problem solving, which requires logical deductive reasoning, and creativity is in the movement of these 'views'. In general problem solving, there is a specific starting point from which the view expands gradually in a definite direction; a node or link, once included, is never discarded. However,

as Takala points out, in creative thinking the 'view' moves spontaneously from one portion of the network to another. Takala (1993) and Nakakoji (2000) suggest that a representational medium developed using a hyperlinked environment may have the potential to encourage the reasoning process.

2. Our Experiences with Virtual Reality for Design Critique

The Immersive Environments Lab (IEL) system at the School of Architecture and Landscape Architecture at Penn State University was envisioned as a surround-screen immersive 3D environment for the personal visualization of models. The specific attributes of this virtual reality system, such as stereoscopic projection, wide field of view and interactivity, were highly regarded by the students. The students, however, went beyond the originally envisioned use and quickly adopted the system for use as a multi-modal presentation space. For example, the students consistently use programs such as Microsoft PowerPoint on one screen to present two-dimensional drawings or renderings, in conjunction with stereoscopic 3D presentations on the other two screens. The use pattern at the IEL suggests that an integrated multimodal approach would best serve at the evaluative stage during the design process, especially in a collaborative setting. While this paper suggests a multimodal approach to design representation, we stress that this should not be at the expense of the key attributes of the virtual reality rated highly by the students.

3. Development of the Multimodal Virtual Environment

The development of the conceptual multimodal virtual reality environment (MVE) followed a cycle of design; usability studies by a focus group using web-based mock-ups and redesign, based on the inferences from the usability study. The focus-group study also addressed a number of human-computer interaction issues, such as view navigation, limited screen real estate, adaptability to varying screen sizes and redlining, among other parameters. This method of development and refinement of tools by observing how they are used is common among ergonomic designers and graphic-user interface developers. The rationale is that potential users are ideally suited to assess a new tool and recommend changes. The design features described here incorporate the findings from the usability study.

4. Design features

4.1. USER INTERFACE

The user interface is envisioned as self-contained and customizable, providing access to representations in various modalities by organizing and cross–referencing them. In earlier attempts at a multimedia system aimed at helping architectural analysis using standard multimedia authoring tools (See Mishima and Szalapaj, 2001), interface elements such as buttons can potentially distract the attention of the user and audience. When using a presentation medium, it is important that attention and cognitive effort are directed at the representations, rather than at the interface. In other words, the best scenario would be if the representations themselves act as the interface and the user interface switches between an organizational mode, where representations are organized hierarchically on the basis of their modalities and their level of abstraction, to the presentation mode. Figure - 1 shows these two modes. The organizational mode was incorporated into the conceptual model based on the findings from the usability study carried out with the focus group.

Figure 1. MVE in Organizational and Presentation Mode

4.2. HYPERMEDIA STRUCTURE

Mitchell (1995) suggested that hypermedia could be used effectively to provide richer associations and cross linkages between representations and also new modes of investigation such as associative browsing. Hypermedia environments have two important characteristics: a hierarchical structure and a navigation arrangement that helps to access the information stored in the knowledge base. Multimodal virtual environment (MVE) is envisioned more as a presentation medium that works with other well-established computer tools and accepts images, animations and interactive virtual reality models. MVE primarily defines an access structure for organizing representations into layers. The criteria for the organization of these representations are left to the

presenter, and they can be based on modality, level of abstraction, or any internally consistent logic decided upon by the presenter. Items from a particular layer are assigned to a specific frame in the display in the default presentation view that can be changed later using a drag-and-drop feature.

In many hypermedia or knowledge base environments, indexing and cross-referencing are achieved by further abstracting visual elements into textual and numeric information (Carrara, Kalay and Novembri, 1992), which makes visualizing and editing the links more difficult. MVE attempts to overcome this limitation by suggesting a visual interface for hyperlinking. Each representation is depicted as a thumbnail and dragging a path from one representation to another can make a link. This feature is similar to the 'routing' function for adding behaviors seen in software such as Internet Scene Assembler software (ISA, 2003). The thumbnail can be expanded to reveal the component structure of a representation, and links can be made from any of the subcomponent to another. The hyperlinking feature of the MVE is revealed in the organizational mode in figure - 1.

4.3. FLEXIBLE FRAMES AND VIEW NAVIGATION

The main objectives for any presentation environment are to reduce the cognitive effort for relating information across different modalities, improve comprehension, and address navigational problems in the presentation space by accessing spatial reasoning (Carpendale and Montagnese, 2001). Also, setting information in its context reflects the functioning of the human memory patterns (Furnas, 1997). Traditionally, the screen real estate problem is tackled by using non-distortion-based techniques or distortion-based approaches such as *Graphical Fisheyes* (Sarkar and Brown, 1993) and *Document Lens* (Robertson and Mackinlay, 1993). The MVE approaches the problem of limited screen display by dividing the interface into a number for flexible frames, as seen in Figure 2). The number of frames and their layout can be defined and the relative size of each frame dynamically adjusted.

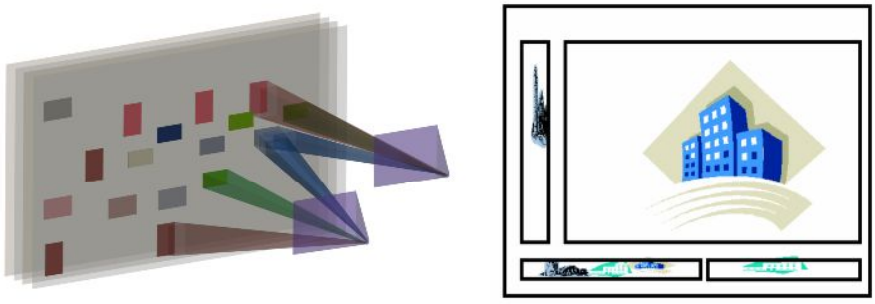

Figure 2. Conceptual idea of view navigation and flexible frames.

MVE attempts to solve the issue of limited screen size and that of navigating the data space of the representations by introducing a new conceptual approach. The display frameset is conceptualized as a larger, all-encompassing view with a set of smaller views nested within it, as shown in figure - 2. The all-encompassing view defines the boundaries of the overall presentation space and acts as a constraint to the maximum screen size, each of the nested sub-views can occupy. The representations are earlier organized in layers that can be thought of as a series of planes with individual representations laid out on them. The focus of any of the sub-views can be changed to include a particular representation on a given plane. By shifting the focus of these sub-views, new sets of analogical information can be presented in the main view. See figure - 2. In the case of information overload, or to shift the focus of the presentation from an exocentric point of view aimed at analogical reasoning to an egocentric point of view, a sub-view can be magnified to occupy the full display area at the expense of other sub-views. Thus by shifting the focus of each of the sub-views, a series of analogous sets of representations in different modalities can be presented to reveal the design for critique or evaluation.

5. Conclusion

This study emphasizes the need for multiple representations in multiple modalities at different levels of abstraction for design presentation and evaluation. It is an attempt to bring together these different modalities to support design presentation and evaluation. The multi-modal environment presented here draws from user experiences and previous literature on hypermedia theory, especially as it pertains to issues of organization and navigation. This research makes the case that a more desirable and realizable goal is to develop computer tools that augment and support the abilities of the designer, especially in overcoming cognitive limitations such as short-term memory and aid-associative reasoning that are critical for design thinking, especially in the evaluation stage of the design process.

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