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To go where no man has gone before: Virtual reality in architecture, landscape architecture and environmental planning

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ABSTRACT

The use of virtual reality has its roots in visual communication science but disparate mechanisms and applications set it apart from the many tools of visualization. This paper reviews the use of virtual reality (VR) environments for research and teaching in the context of three disciplines: architecture, landscape architecture and environmental planning. As opposed to other uses of virtual environments, for example, in the health sciences or engineering, simulations using virtual reality theatres or labs in the three fields we explore are used to display inaccessible realities. VR environments are typically used in these fields for planned and designed realities, not yet existent or with nonexistent components. Each field has different reasons for spatial or temporal inaccessibility to reality, prompting the need and eventually the capability to achieve various levels of accuracy in the virtual setting. We describe current VR research opportunities and challenges in each discipline and emphasize what they can gain from sharing virtual reality systems for research and education.

1. Introduction

A recent book entitled *Visual Research Methods*, edited by Margolis and Pauwels (2011), covers topics so broad that it is hard to get a sense from the book just what visual studies entail. Are they typically studies in communication? Sociological or anthropological inquiries? All types of media are covered in this book, from the rhetorical use of images to social and cultural expressions depicted in websites, video, cartography, semiotics and more. It seems that the word "visual" added on to almost every discipline in the sciences, both social and natural, would describe work being done. As an opening to this special issue on the use of virtual reality (VR) and particularly one showcasing the interdisciplinary nature of visualization, we highlight the contribution of VR to visual studies within three subfields of the more general design professions.

Unfortunately, there is little integration with respect to the contributions of visual research methods to different disciplines (Hansen & Machin, 2013; Lange, 2011; Pauwels, 2014); this spills over into the design professions so that each sub-discipline finds itself reinventing the wheel. It is our intention, therefore, in this review, to describe the use of VR for architecture, landscape architecture and environmental planning while underscoring research and educational aspects that are common to visualization tools. We look at the use of visual research methods applied for studies of VR as relevant for the design disciplines. Subsequently, we posit that the use of VR for architecture, landscape architecture and environmental planning can aid in making visual studies in these fields more interdisciplinary.

By and large, the use of VR in laboratories for professional design and research purposes facilitates access to situations that do not (yet) exist. Although lab applications are sometimes used to determine visual preferences in regards to extant views (or images) in a controlled environment, a frequent purpose is to inform about future visual change. Such anticipated changes may be either planned – such as for reuse of existing buildings in urban design (e.g., Gill, Lange, Morgan, & Romano, 2013) – or expected, such as to solicit a response from stakeholders regarding climate change (e.g., Sheppard, 2012).

For this review, we start by describing the evolution of VR within the context of visual research methods and paradigms and then look at each of the three disciplines of concern – architecture, landscape architecture and environmental planning – with reference to the type of visualization needed. We consider the meeting of these needs through the use of a "theatre" or laboratory facility. The widespread and growing existence of such facilities allows the identification of common research themes and gaps as well as challenges to the use of outcomes and products in praxis.

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2. Background

Virtual reality is ultimately a type of "visualization", a technique which has experienced a recent boom in professional and academic literature. Two special issues, one published in *Environmental Communication* (2013; Vol 7(2)) and the other in *Landscape and Urban Planning* (forthcoming), showcase visualization. The former offers a collection of scholarly work now emerging and using various methods in the field of visual environmental communication research. The latter provides a critical view of visualization. Although visualization for environmental and urban planning has numerous dimensions and applications in the literature, there is invariably some mention of virtual reality (e.g., Ball, Capanni, & Watt, 2008; Bishop, Wherrett, & Miller, 2001; Ghadirian & Bishop, 2008; Lange, 2011; Paar, 2006; Portman, 2014).

A cursory search (conducted May 2014) for the keyword "virtual reality" in the Academic One online database yields 1677 academic papers on the topic, ranging broadly from the field of physical therapy to education, from interior car design to treatment for weight loss and more. The large volume of academic papers indicates the widespread use of VR, but fails to give an indication of what concerns us for this review: research on VR for urban design. A search for "virtual reality" in *Design Studies* (conducted June 2014) resulted in 94 papers, most related to architectural design. This second search indicates a significant volume of research related to the use of VR for design. Some of these address research being conducted on VR in laboratories and theatre-type situations. We assume that to make sense of the term that engenders such a large volume of literature requires examining the contribution of virtual reality to visualization methods.

A common thread between visualization and VR is the emphasis on the visual sense as a tool of communication. Tufte (1990) describes visualization as a medium for clarifying certain complex data that has great advantages over the written word or voice alone. The visual sense is by far the dominant component of human sensory perception (Bruce, Green, & Georgeson, 1996; Rose, 2012). Scholarly work on visualization promotes expanding the sense of the visual, incorporating all types of representation – television, film, photographs, across different fields, and including the broadest range of representations possible – from maps to photos to visual representation of data in graphs and tables (Hansen & Machin, 2013; Valiela, 2009; Ware, 2013). Although simulating reality may be the crux of the VR experience, the use of VR for design purposes leads to an expansion of this definition, based on the "real" simulation or replication, but also going beyond it.

Research on the effectiveness of various technologies as simulation tools for design is on the rise; novel virtual world platforms and technologies developed for all types of applications during the last decade – like Second Life and World of Warcraft – have drawn the attention of researchers including some from the design disciplines (e.g., Koutsabasis, Vosinakis, Malisova, & Paparounas, 2012). Frequently visual quality of these games is similar or even superior to that used in professional design disciplines and VR laboratories. However, despite VR's potential contribution to professional design and planning (Gill et al., 2013; Paar, 2006; Silvestri, Motro, Maurin, & Dresp-Langley, 2010), it is hard to find current *interdisciplinary* research aimed at improving VR techniques or helping define across disciplines, what we mean by "virtual" or even by "reality".

Over a decade ago, Simpson (2001) compiled a bibliography of virtual reality and urban simulation in the planning literature. Looking for instances in which simulation technologies have been implemented for improving urban and regional planning, the author describes urban simulator labs (such that at UCLA) designed to simulate cityscapes. Visual simulation models described developed in such labs used a combination of computer-aided design and geographic information systems (GIS). Simpson concluded that the small number of research institutions applying these technologies for research and education indicated that cross-discipline application to planning lagged behind system capabilities due to high costs. Pietsch (2000) makes a similar observation about implementation by planning authorities lagging behind research on technologies. Visualization labs are more commonplace today such that opportunities exist to reduce the lag. In any case, an applied research agenda must be clearly articulated and this includes one dedicated to cross-discipline design as distinguished from other visual communication research.

In a broad sense virtual technologies have engendered changes in how we understand the world, i.e., 'going-to' or 'visiting' websites, writing or reading of Facebook® 'walls'. These phenomena have been included in visual communications research that investigates how virtual technologies, especially those with emphasis on the visual sense, have changed our lives; for example, how multi-media representation has generated a host of virtual locations, situations, transactions, relationships, etc. (Wagner, 2011). These environments, though perhaps not originally envisioned as such, replace reality rather than replicate or simulate it. So what exactly are we referring to when we consider VR as a type of visual communication for urban design?

2.1. Virtual reality defined

A standard definition of "virtual reality" is hard to find. The Webster Collegiate Dictionary (1991) has no definition for it whatsoever.[1] A little over two decades later, we have the following definition: VR is a "computer-generated environment that, to the person experiencing it, closely resembles reality" (Collins Dictionary, 2014). Other definitions of VR emphasize the participatory aspect whereas VR is "experienced" (as opposed to "viewed") and it is synthetic or fabricated. Addressing the later point, Regenbrecht and Donath (1997) have defined VR as "the component of communication which takes place in a computer-generated synthetic space and embeds humans as an integral part of the system…". Both these points – experience and synthetic – are highlighted by Sherman and Judkins's (1992) five "i"s of VR: "intensive, interactive, immersive, illustrative and intuitive." These characteristics seem to be a good starting point for a definition. Without one or more of these characteristics there is no VR.

But how far does the fabrication or synthetic element go? Can VR be completely fabricated or at most a copy, or simulation, of reality? Debatably, virtual reality connotes a greater synthetic component than do related techniques described by the terms "mixed reality" and "augmented reality (AR)".

Mixed reality describes a continuum between digital experiences that depict the completely real world to those that are completely synthetic or fabricated; it includes both AR and VR (see Fig. 1). Augmented reality dynamically overlays virtual images on images of the real environment such that the real environment is still part of the visual display seen by the viewer (Guo, Du, Luo, Zhang, & Xu, 2008); when the viewer moves in the AR environment, information changes in response. Predating other authors on the topic, Milgram and Colquhoun (1999) distinguish between two main types of AR: one which involves the use of a head-mounted display worn by the user and another covering any situation in which the real environment is "augmented" by means of virtual (computer graphic) means. Azuma (1997) defines

[1] The closest term in the Webster Collegiate Dictionary (1991) is perhaps "virtual image" (origin: 1859) defined as: "an image (as seen in a plane mirror) formed of virtual foci".

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