Applications of Virtual Reality Technologies in Architecture and in Engineering

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ABSTRACT

Virtual reality (VR) is a technology which permits to create virtual objects and 3D virtual worlds which are hosted on the computer’s memories. It is indispensable in critical simulation, for instance in military training, in surgical operation simulation, in creation of environments which could set off phobias (in psychiatry), or in realization of virtual prototypes, for instance in industrial design. The aim of this paper is to present how VR technologies also find excellent application fields in architecture and in engineering. For instance, in the teaching of the basic concepts, in techniques of graphic rebuilding for the building restoration, in realization of virtual visits inside buildings, and in urban generative processes simulated by computer. Another use of the virtual reality is in the introduction of a new kind of architecture: Virtual Architecture, strongly connected to the Information and Communication Technology (ITC) and to the Internet, and in the virtual prototyping which connects engineering and architecture.

Keywords: Architecture, Engineering, Three Dimensional (3D) Model, Three Dimensional (3D) Virtual Worlds, Virtual Architecture, Virtual Prototyping, Virtual Reality (VR)

1. INTRODUCTION

Virtual Reality (VR) is a technology which has various application fields (from education to the psychiatry) (Pantelidis, 1995, Popovici et al., 2009, Kralen & Poelman, 2010, Malbos et al., 2013, Parsons et al. 2013, Tsoupikova et al., 2013). Its hardware components are conceived for a correct human interface and they consist of a set of visual display apparatus (for example, head mounted display), input devices (for instance, data gloves), and position sensors (Sherman & Craig, 2002). A virtual reality system has the following three primary requirements (Rosenblum & Cross, 1997): a) immersion (which permits to the user the physical involvement, capturing exclusive visual attention and responding to three-dimensional input. For example, through a head-tracker, 3D mouse, data glove, or fully instrumented body suit); b) interaction (through the three-dimensional control device to “navigate” in the virtual environment); c) visual realism (which is the representation of the virtual world using computer graphics techniques).

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Figure 1 shows the reality-virtuality continuum by Milgram and Kishino (1994), where Augmented Reality (AR) is one part of the general area of mixed reality (van Krevelen & Poelman, 2010).

In particular, van Krevelen and Poelman affirm:

*Both virtual environments (or virtual reality) and augmented virtuality, in which real objects are added to virtual ones, replace the surrounding environment by a virtual one.* (van Krevelen & Poelman, 2010, p. 1)

Benford et al. (1998) classify AR as separate from both VR and telepresence, as shown in Figure 2 (Benford et al., 1998).

This paper describes two application fields of virtual reality. It is organized as follows: section 2 shows the use of VR in architecture, section 3 presents VR in engineering, section 4 describes the conclusions and the future trends, and the section 5 is dedicated to the references.

### 2. VIRTUAL REALITY IN ARCHITECTURE

Different disciplines involve the application of VR. Recent studies have recognized the potential of VR in education and in different disciplines (Win, 1993; Pantelidis, 1995; Byrne, 1996; Youngblut, 1998; Ainge, 2000; Kaufmann et al., 2000; Mantovani, 2001; Gerval et al., 2002; Shin, 2004; Sala & Sala, 2005; Popovici et al., 2009, van Krevelen & Poelman, 2010, Matsuda et al., 2013, Soares Calado et al., 2013, Tsoupikova et al., 2013). Virtual Reality offers benefits that can support the education and the design project, in particular in the faculties of architecture.

Sala & Sala (2005) applied VR technology in a course of mathematics oriented for architectural studies and dedicated to the connections between this discipline and the world of arts and design. VR has been used firstly to help the students to visualise in three dimensions, since this is arguably the most difficult part of understanding architecture. In this case, the students have used the Virtual Reality: to study and to manipulate virtual polyhedra, to observe and to manipulate virtual molecules of C_{60} and C_{70} (fullerene molecules), to analyse the symmetry inside the architectural shapes, to observe and to manipulate 3D virtual models of geodesic domes, and to study their analogy with the fullerene molecules (Sala & Sala, 2005).

In the same faculty, VR is also integrated in multimedia presentation to describe “virtual 3D walkthroughs” in the buildings, in virtual museums and in archaeological sites. This educational approach, based on the use of VR, is important, because in the next future the architects will design themselves virtual environments, virtual buildings and reorganize new spaces (Prestinenza Puglisi, 1999).

Broll et al (2004) present ARTHUR project which is oriented to the architectural design and urban planning. It is an interesting approach which develops an augmented reality interface for round table design meetings, organised by University College London. The system supports the different phases of architectural design and urban planning. The goal is to provide an environment and tools to support close collaboration between architects for complex design and planning decisions (Figure 3).

The powerful of computer systems connected to the evolution of virtual reality technologies have introduced new opportunities in the architectural field, for example to realize braver designs and new environments. Figure 4 shows the virtual environment conceived by Hani Rashid and Lise Anne Couture (Asymptote group): The New York Stock Exchange 3D Trading Floor (NYSE 3DTF) as a reinterpretation and transformation of the existing physical trading environment. About the project they stated:

*The idea was to create a visual environment through which traders can navigate, analyze, and act upon at-a-glance. Trade actions are very dynamic* (Andia & Busch, 1999).

NYSE was the first business application of an interactive virtual architecture. Rashid (2003) affirmed:
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