E-LEARNING CAAD WITH VR AND LANDSCAPE ARCHITECTURE RENDERING FUNCTIONALITY

E-LEARNING CAAD CU FUNCȚIONALITATE DE REALITATE VIRTUALĂ, ARHITECTURA ŞI INTERPRETAREA PEISAJULUI

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Abstract: *Possible applications of Virtual Reality (VR) in Digital Architecture (DA) and Landscape Architecture (LA) projects include collaborative design, Computer-Aided Design (CAD) cognition, as well as haptic rendering with e-learning functionality. Following the current trends in digital architecture, this paper aims to present VR technology as a medium for communication among members of CAD design teams, and as a tool which successfully be used for presentation purposes in landscape architecture projects. Also, the e-learning functionality embedded in digital architecture projects is demonstrated using haptic rendering functions. The proposed methodology is based on widely available off-the-shelf software tools which can be used by creative teams to support visual studio projects in architecture. Finally, a case study related to a small urban area in Thessaloniki, Greece is used to demonstrate the functionality of the proposed method.*

Rezumat: *Posibilele aplicații ale realității virtuale (VR) în proiectele de arhitectura digitală (DA) şi arhitectura peisajului (LA) include colaborarea desenelor, cunoştințe de grafică asistată de calculator (CAD), precum şi interpretarea funcțională prin e-learning. Urmând direcțiile curente în arhitectura digitală, lucrarea de față îşi propune să prezinte tehnologia VR ca pe un mediu de comunicare între membrii echipei de utilizatori CAD dar şi ca pe o unealtă de succes care poate fi folosită în prezentările rezultate din proiectele de arhitectură a peisajului. De asemenea, funcționalitatea e-learning-ului implementat în arhitectura digitală este demonstrat prin funcțiunile de interpretare. Metodologia propusă se bazează pe disponibilitatea mare a instrumentelor softului off-the-shelf care poate fi folosit de către o echipă creativă ca şi suport pentru un studio vizual al proiectelor de arhitectură. În sfârşit, este prezentat un studiu de caz pentru o mică zonă urbană a oraşului Thessaloniki din Grecia care să demonstreze funcționalitatea metodei propuse.*

Keywords: *virtual reality, CAD, digital architecture, landscape architecture.*
Cuvinte cheie: *realitate virtuală, CAD, arhitectură digitală, peisagistică.*

INTRODUCTION

Virtual Reality (VR) in Architectural sciences like Digital Architecture (DA) and Landscape Architecture (LA) has certain advantages as a presentation tool compared to other traditional solutions like 2D drawings, 3D models, images and video. Using the technology of VR, not only the present situation can be visualized, but also the future and/or the past of a study area can be imagined from different viewpoints.

The fact that there are no identical definitions of Virtual Reality in the literature, attributes the different conceptions researchers have been expressed during the last decades. Jaron Lanier seems to be the first who gave a precise definition of VR: "An interactive, three-dimensional environment generated by a computer in which a person is immersed" (LANIER et al., 1989). A more recent definition given by Manetta and Blade is more structural and gives more emphasis on moving capabilities (Navigation): "Virtual Reality: A computer system used to create an artificial world in which the user has the impression of being in that world and with the ability to navigate through the world and manipulate objects in the world" (MANETTA &

BLADE, 1995). The underlying hypothesis is that the necessary prerequisite for a system to be considered as a virtual reality application is free, physical navigation by the user in a three-dimensional environment generated by a computer and also interaction between user and environment.

Apart from the search for satisfactory definitions, it is found that not all VR applications are necessarily associated with the use of expensive equipment such as gloves, Head-Mounted Displays (HMD) and body suits. These applications are called Desktop VR. On the other hand, fully immersive applications allow users to become integrated into a virtual world with almost all human senses activated but they have high cost of maintenance

MATERIALS AND METHOD

VR in Landscape Architecture: Methodology

Designing and planning a virtual Landscape Architecture scene is a complicated task, especially if it is taken into account the fact that the members of the design team can be spatially separated. The current project, as any other in this field, is not only a drafting piece of work. It deals with the standard Landscape Architecture methodology, the collection and management of digital and in-print material, database and VRML source code development. The study of 3-D scenery modeling and techniques based on digital images, object-oriented graphic databases of 3-D parametric models and geometric/topologic constraints is an active research area (STYLIADIS et. al., 2003; STYLIADIS, VASSILAKOPOULOS, 2005). Other issues the creation team confront are the rendering of the scenes, the architectural complexity of the objects, the perspective representation and the insertion of three dimensional sound. Although there is no standard methodology widely accepted for developers to follow, some basic steps of the methodology followed by this project can be mentioned below.

Preparation

At the beginning, all the available resources (images, drawings, video, texts, interviews, GPS data and topographical maps) of the study area are overviewed in line with the scope of the project. Other important factors like existing physical resources, history and particular characteristics of the study area and the surroundings should be recorded. At the same time, certain urban planning limitations and financial information are taken into account

Software Tools

The set of software tools finally selected for the design phases of the virtual scene is the outcome of a short research over the Internet about the available software. Important factors for the selection of software tools were:

- The professional potentialities of the software
- The drafting accuracy and the easiness of restoration
- The learning time and effort normally needed by a moderate designer to be able to use the full power of the software
- The existence of VRML/X3D exporter embodied into the CAAD software
- The rendering quality (texture mapping support, lighting effectiveness, reach library of materials, rendering speed)
- The support of compatible file formats for input/output
- The previous knowledge and experience of the creation team

Information gathering and site analysis

First, all relevant information is selected, like city plans, maps, aerial photographs, video shootings, etc of the studying area and the surroundings. Also, information is selected regarding the culture, history and the aesthetic resources of the site. Because of the poor quality of the 2D drawings usually obtained from the municipalities, extra measurement sessions are imported into the team's schedule. Measurements of street furniture, road widths and existing buildings, monuments, etc took place with conventional instruments. Diagrams about traffic flow, existing planting and space usages are created in 2D. The gathered information is analyzed in relation with the scope of the design, in order to obtain a complete view about the existing conditions of the study area and the achieving goals.

Concept planning

Concept planning is a process which is characterized by collaboration and creativity.

Solutions are provided through exchange of ideas among members of the creation team, clients and other participants. The solutions are evaluated in order to choose the most appropriate ones. Concept planning is not totally isolated from drafting processes; rather it is more like a circle process among those two phases.

Drafting Process – (Scene development and LOD Issues)

Every virtual landscape environment that is designed has one or more scenes. A scene can be a room, a park, a building, or a whole city. The shape, size, material, position and orientation of 3D objects is important considering architectural concepts like unity, rhythm, proportion and symmetry (LAMMEREN et al., 2002) and aesthetic consistency. By breaking down the whole scene into separate 3D components make possible to have the necessary flexibility of major alterations during all phases of the creation.

During drafting phase, CAD software found on the market is used to construct the imaginary or existing architectural elements. In case of existing buildings, feasible methods like 3D reconstructing from digital images using geometric constraints can be used to obtain the VRML solid (exterior only) model of the building (HEUVEL, 2003). Today improvements in sensor technology allow the acquisition of high quality digital images (Kazakeviciute et al., 2005) for texture extracting and use in 3d Models.

As stated before, information Intensity deals with the level of detail (LOD) and this affects the quality of the presentation. Usually, a lot of rotations and translations can overload a computer system. To control the overload conditions, in order to keep the frame rate of the final display high, each 3d object with complicate geometry is represented in the scene with different LOD, depending on the avatar proximity. As an example, consider the trash can 3d model. Initially it is loaded into the scene as a simple box, since details cannot be viewed from long distances. By the user proximity (triggering proximity sensor), this object is replaced by the maximum LOD 3d object, showing the trash can in maximum detail (see fig.1).

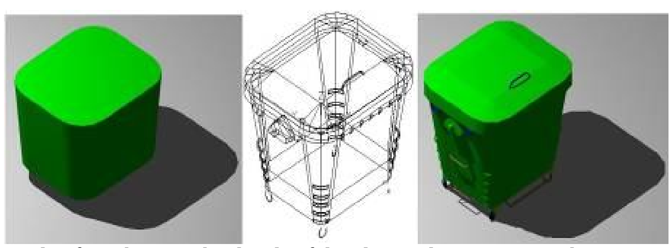

Figure 1. Example of an object with 2 levels of detail: Simple geometry with minimum LOD (left), original object in wireframe (center), object with maximum LOD (right).

In some occasions (massive and complicated objects) various levels of detail are defined for given geometries. Browsers, or stand alone vrml players, automatically choose the appropriate LOD level based on a set of predefined distances between object and avatar. The simple algorithm which chooses the most appropriate LOD for a given object at any time during navigation is based on the formula (Web 3D Consortium, 2004):

$$LOD(l) = \begin{cases} LOD_o, if.l < R_o \\ LOD_{i+1}, if.R_i <= l < R_{i+1}, for -1 < i < n-1 \\ LOD_{n-1}, if.l >= R_{n-1} \end{cases}$$

where,

LOD(l): winner LOD
LOD_0, LOD_1, LOD_2, …, LOD_{n-1}: n values (object instances of various LOD)
R_0, R_1, R_2, …, R_{n-1}: ranges which partition the domain from 0 to infinity.
l: avatar's distance to object

VR in Landscape Architecture: An Application Example

For the reader's convenience, the study area of the application example is a 75x93 m2 located in front of the historic port of Thessaloniki and currently is used as a parking area. The starting point of the design process is the 2D drafting of the basic concept of the area (see fig.4 & 5a,b) including planting, business and sport activities, existing elements and park furniture.

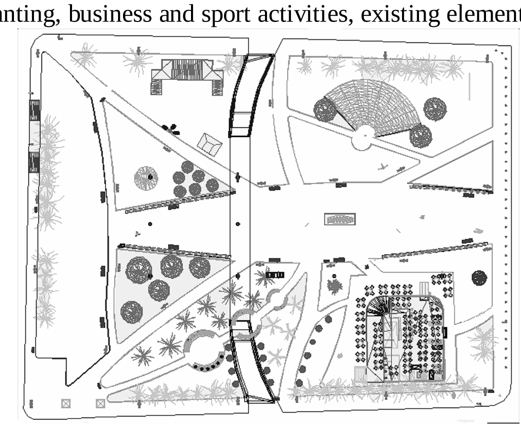

Figure 4. A basic concept plan of the recreation area.

The case study presented below was mostly engineered using the 3D-Studio Max (Autodesk Inc) software package, while parts of it were drafted with AutoCAD 2006 (Autodesk Inc) and imported into the main scene as external files. The original 3D model was enriched with VRML scripting code and finally exported as a wrl file capable of reproduction in widely used browsers.

VRML plug-in players implement a Graphical User Interface (GUI) for navigation through the virtual scenes and for applying operations on the 3D objects. After having tested and evaluated several plug-in players for VRML, it was the Cortona (Parallel Graphics) which was finally selected as one of the most appropriate for the popular browsers Internet Explorer and Mozilla Firefox.

In addition to the starting viewpoint (camera), a set of additional cameras are imported into the scene. Camera nodes in VRML define exact positions from which to view a scene and some of their parameters can give effects like special effect lens (fish-eye). Another used effect was the linear fog to give to the overall scene a better depth of perception.

Because the output file sizes an exceeded the expected, the Win-gz (copyrighted by Bob Crispen) or similar compression utilities can be used to compress the original file with very satisfactory compression rates. The small file sizes keep the download time short even at a moderate bandwidth.

(a) (b)

Figure 5. (a) 3D model of the proposed concept plan (3d scene) (b) Study area (before-after).

Taking into consideration that the typical target audience of VR landscape architecture projects is composed by people with at least basic computer skills, a set of system variables was initially set. Those system variables include viewpoints (cameras), navigation adjustments, speed and collision detection regulations. Advance users can change those values at a later time (navigation/execution time).

After a few cycles of execution tests in web browsers, few more adjustments can be made to ensure the efficient interpretation. Four digits of precision are selected for projection of the geometry and 15-20 frames per second are considered satisfactory to achieve a realistic as well as a comfortable navigation, given the total size and complication of the scene.

RESULTS AND DISCUSSION

VR functionality has been an area of increasing research especially in architecture related fields where visualization has a huge effect. VR is both an artistic and a scientific language that can be used during creation, presentation and checking processes. Also, it can be used as a tool to offer real prospect for learner participation in educational activities related to CAD and virtual studio projects.

The methodology presented in here, followed by an application example, illustrated how desktop VR technology can address the challenges to experiment with scenes in real visualized projects. More efficient user control and management of scene parameters is desirable for the future. In such a system students could locally modify values of variables in real time. The possibility to change 3d model appearance and behaviour on demand, or study the dynamic alteration of the whole scene over time/seasonal parameters is the fourth dimension in addition to the haptic rendering functionality. It will be possible for learners/designers to dynamically retrieve the geometry and texture of planting from a floral database. Given the time and GPS global position of the study area, the examination of lighting conditions (artificial lighting and sun) during morning, midday, afternoon and night could be possible at run time.

Figure 6. (a) Human-scale exploration (walk) to study lighting conditions (here manually adjusted at design time).

New methods are invented to take advantage of the VR technology. In order to choose between competitive ideas, VR technology and haptic rendering functionality made possible to locate advantages and disadvantages, strong and weak points of the concept plans. Also it allowed a better understanding of the flow of movement in the area, from the pedestrian's point of view. It would be difficult right now to get a clear answer if the proposed methodology results better urban and landscape implementations in real world than the conventional methods. All conclusions are relied on the assumption that 3d real time navigation is helpful for communication among experts and have a positive effect on public participation. To what degree those methods are effective remains a task for further research. Today, it could be stated that apart from the educational benefits of 3d visualized projects, VR functionality is to additionally support the decision making in Landscape Architecture planning by demonstrating major key-points of the concept.

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