Teaching Virtual Environment Design

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In a previous paper, the authors considered the design and development of virtual environments (VEs) pointing out the need for a new direction within architectural education, leading towards a generation of VE architects. It was suggested that there is an urgent need for educating practitioners who will contribute to the design of 3D content for multimedia and virtual reality applications. This paper focuses on the application of these principles and ideas into the structure and methodology of three VE design courses, taught by the authors. These courses are by no means suggested as exhaustive examples of teaching this subject. They are seen as preliminary approaches, adapting to the educational context they are integrated within. Bearing in mind the problems relating to teaching large numbers of students with a design studio approach, difficult concepts, resources availability, fighting misconceptions, techno-phobia the following areas are discussed in the hope that they will contribute to VE design curricula in the near future.

Keywords. *Virtual Environments, virtual environment design, architectural design, architectural education, curriculum*

Introduction

On an eCAADe'99 conference paper, the authors considered the design and development of virtual environments (VEs) and the way that it relates to traditional architectural education and practice. It was suggested that there is an urgent need for educating practitioners who will contribute to the design of 3D content for multimedia and virtual reality applications.

The design of space in a VE is largely an architectural problem and as such, architectural design should play an important role in educating VE designers – "virtual architects". The importance of other disciplines intrinsically related to the issue of VE design, is also stressed. The disciplines involved were identified as being software engineering, cognitive ergonomics, perceptual psychology, graphic design, mechanical and electronic engineering.

This paper focuses on the application of these principles and ideas into the structure and methodology of three VE design courses, taught by the authors. These courses are by no means suggested as exhaustive examples of teaching this subject. They are seen as preliminary approaches, adapting to the educational context they are integrated within.

Virtual Environment Design Considerations

Recent technological advances have enabled us to use computers for representing real-world phenomena in a symbolic, schematic or realistic, multi-sensory way and interacting with such representations via human-computer interfaces (HCIs). Walker (1990, p.444) has suggested that the latest generation of HCI is a virtual environment (VE), which "provides users a three-dimensional interaction experience that includes the illusion they are inside a world rather than observing an image". Humans therefore, interact with computers via human-computer interfaces (HCIs), in ways that give the interaction experience a predominantly three-dimensional, spatial character. These issues are urging us to consider the growing need for designing space in virtual environments and the consequent need for professionals adequately equipped to perform this task. Architects could play an important role in this, as well as in the development of the infrastructure for generating cyberspace (a three-dimensional, on-line, network of computer generated worlds as defined by W. Gibson's, 1984), as a new spatial aspect of life and communication in the next millennium.

The theory and practice of architecture, in the traditional sense of the word, are being influenced by electronic media, which are currently used by many architects in the process of design. Novel and unique architectural forms, which would probably never have been designed by traditional media, are being designed by computer-based systems. However, the main relevant change that has happened in architectural curricula over recent years has been the introduction of computing and CAAD classes. Recently, there have emerged a series of higher education courses, which partially address the issue of designing VEs. It is worth noting that the majority of such undergraduate (BSc and BA) courses are organised within computer science departments, whereas faculties of art, design and architecture organise the postgraduate (mainly one year MSc) courses. Although the existence of these courses confirms the previously identified need for educating people in the design and development of 3D interactive content, the knowledge they offer is usually seen as supplementary to traditional architectural, design or computer science education.

The disciplines of architectural design and virtual reality technology may be related firstly in architectural design employing virtual reality techniques for aiding the design process leading towards systems that support the design of form within a VE. Such a system is very significant because it provides the designer with a tool contemporary CAD systems lack; that is, visual feedback of what you design, when you design it, as if you were inside the designed environment (Smets et al., 1995, p.204, Kurmann et al, 1997, pp.809-819).

And most important, *virtual reality may employ architectural design knowledge, for informing the design of virtual environments*. VEs are, by definition, built on the principle of imitating the spatial experience afforded by real environments. Consequently, a VE is experienced by humans as a kind of three-dimensional space, comprising several objects and events, which do not necessarily have real-world counterparts.

Space in a VE is infinitely expandable and physically limited only by the computational power of the system, which supports the VE. There may be no need to protect participants from natural hazards but there is still a need for delimiting space in a VE in order to make it

- more legible and therefore
- easier to navigate easier to remember when experiencing a VE more than once.

In order to delimit space in a VE, as we do in the real world, this paper argues that there is a need to impose a certain form and structure onto the space. For the purpose of doing so, we need to develop an architectural framework, as a system of meaningful spatial elements in this VE, ultimately making our interaction and navigation within the VE a structured

and meaningful experience.

Virtual Environment Design Courses: Case Studies in Greece

The authors are currently teaching three courses that differ in terms of the maturity, experience and knowledge of the students involved (undergraduate versus postgraduate architectural degree level) as well as the overall direction of the approach (a course is taught in a computer science department). An analysis of the courses curricula, the students' understanding and projects carried out and finally the future plans are presented below. It was decided to include a course, taking place in a computer science department, since it also deals with the issue of VE design.

University of Thessaly (UTH) – Department of Architecture

Undergraduate students of architecture at the University of Thessaly, Volos are introduced to cyberspace and in particular "Virtual Reality" with a compulsory sixth semester course. The aim of the course is to familiarise students with cyberspace, as is and not as it is hyped, focus on VR and in particular on understanding, analysing and designing virtual space. The Dept of Architecture is on its third year leading to the first year the course is run.

The course within the department curriculum: There is an emphasis on new technologies and their integration in the design curriculum. There is a greater understanding that the digital / virtual domain is an emerging field and architects should play an important role shaping it (Bourdakis and Charitos, 1999).

Students' prior knowledge: Students, as early as the first semester, are introduced to digital media, analogue video editing and presentation techniques. Initially they use time-based media as a tool for understanding space and spatio-temporal relations as part of the main studio projects. By the end of the second year, students have designed scenarios for small projects, filmed and edited short videos, built websites and animations and modelled 3D spaces as part of Art and Multimedia Technology compulsory courses. It should be noted that at UTH, even courses not traditionally linked to multimedia output presentations, are often employing such techniques.

Courses concluding the VE design cycle: An elective course on multi-user space design, tackling its particularities, design approaches, new techniques and tools employed is planned for the fourth year. The digital orientation of the curriculum wraps up with a final year elective architectural studio project that is utilising digital techniques varying from CAAD, interactive 2D graphics, VR, non-linear video, etc.

Structure of the course: Bearing in mind the large number of students attending the course (approximately one hundred!), the only acceptable approach is a combination of lectures and tutoring. The theory is organized in a series of 2-hour lectures. Half way through the semester, students start working on the main project in groups of 4 to 6. Throughout the rest of the semester, lectures are combined with tutorials on student's work, analysis of problems, solving theoretical and technical questions.

Lectures start with an analysis of cyberspace, its properties and applications followed by a focus on VR and analysis of contemporary application environments. Halfway through the semester, the students are already familiar with the available digital design tools and are introduced to aspects of VE design. The lectures conclude with a focus on the application of VR technologies in design (urban and architectural) presentation of advanced design tools and look into the future of VE design (information society, etc)

Supportive material: Due to the nature of the taught material and the unfamiliarity of the students with the topics' particularities, it was designed to deliver the course material online. Lecture slides were prepared in html-formatted pages, integrating images, video clips, Quicktime VR movies and

VRML worlds, all structured in well and clearly defined entities. Each lecture included a list of relevant web resources, online papers and book references as well as the 10-15 pages PDF text (part of the course book not yet published). As a result, students may access all the course material from the departments' computer lab or from home (audiovisual material is available in two resolutions one for network access and one for modem dial-up).

Student projects are grouped in two relatively distinct categories:

- Analysis of abstract processes and the research into modelling them i.e. the process of thought (a 3D map of the relevant active parts of the brain in relation to the input / output devices), the expression of feelings, etc.
- Information visualization presented in various forms ranging from virtual exhibition spaces, doom like navigational spaces, mazes based on the use of colour and certain verbal analysis, all the way to educational uses of VR (modelling solar systems, virtual museums, etc).

Following the students' final submission, all the projects with their supportive material on web pages are organised in a web space using portals and spatial organisation for making the work navigable and generally accessible to others.

Observations: At the beginning, students are puzzled by the subject mater in general and the whole concept of cyberspace. Whilst still struggling to follow the theory presented, the accompanying video clips and virtual worlds presented help in understanding the particularities and problems involved in designing such spaces. The great shock is experienced when comparisons to "real" space are made. It is extremely difficult for students to take the step into non-Euclidean space, realize the implications of lack of gravity, challenge the need for walls and windows to protect from the non-existent natural phenomena, floors to walk on to, glazing and roof lights to bring light into the space, etc. Once this break is accomplished, students seem more relaxed and the only restrictions are the knowledge of the technology and the tools.

Due to their experience with TBM structures and scenarios, the other problem faced regularly, is the tendency to built scenarios and VE spaces that are simple narratives but not interactive. This is a hard problem to tackle since they have no prior experience. The author noticed that this phenomenon happens more with students that tended to miss lectures and try to come up with ideas from the already gained experience, missing the whole point of the course.

A final observation relates to students that are generally proficient with the software tools. The CAD wizards, the ones that produce the best renderings and most elaborate 3D models have a tendency to come up with the most uninspiring ideas. A typical case of tool and technology oriented conceptual design. Unsurprising, as other tutors usually accuse them for lack of ideas and design goals as well.

Outcome – proposed changes: Drawing to the end of the first semester of teaching this course, the author acknowledges the need for a slower and more focused start to the semester plus a mid-term orientation that will help students come up with project ideas that are more educational, entertaining and interesting to them. Tutorials and project work is a problem that cannot be addressed in the 3 hours dedicated to the course on a weekly basis. As a result, students are encouraged to work on groups of 4 to 6 and extra tutorial sessions are organised each week creating extra problems to the already tight timetable of the students

National Technical University of Athens (NTUA) – Department of Architecture

In the Department of Architecture – National Technical University of Athens, VE technology and design is being introduced as a section of a post-graduate course on "Utilising new media for creating spatial representations". This course[1] aims at investigating the manner that time-based media are being used for the purpose of creating spatial representa-

[1] *Associate Prof. N. Laskaris is responsible for this course and the modules described above are taught by Dr. D. Charitos.*

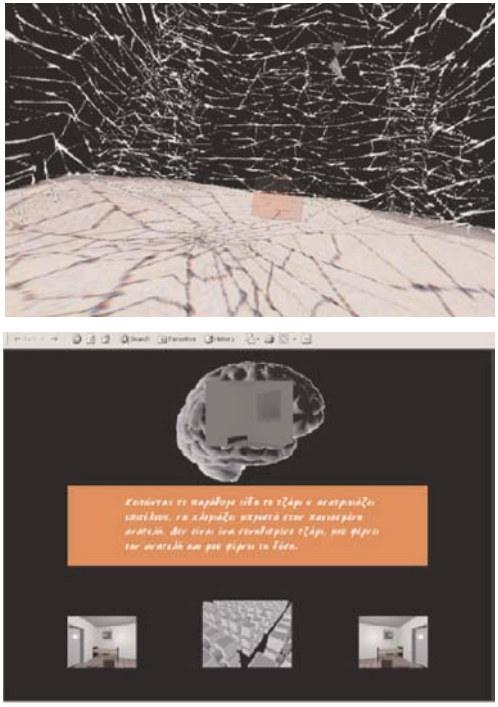
tions. The section regarding VE design in particular aims at revealing the potential of VR for creating representational environments and the intrinsic characteristics of space within such worlds.

How the course fits within the overall department curriculum: VE design is merely a section of one of the several elective courses that the MSc titled "Architecture – Space – Culture" consists of. In the context of the overall course, VEs are seen as the latest and very significant innovation in the field of time-based media, having great potential for creating spatial representations.

Structure of the course: The overall course builds on earlier history and principles of cinema and generally follows a structuralist approach regarding the use of time-based media like film or video. Video art and installations are considered with relevance to their potential for creating spatial experiences and representations. It goes on to present hypermedia technologies and their significance regarding the manner in which 2D or 3D content can be structured in a computer-based representation. Finally, the course focuses on VR technology and its relation to architecture in general. Firstly, theoretical aspects of VE design are considered and the manner in which the medium of VEs may enable the creation of non-realistic synthetic communication environments is discussed. An attempt to understand the VE design process through identifying relations with the processes of creating by utilising time-based media like film and video is made.

Prior knowledge of students relevant to the course: The majority of students following this course are architects, artists or civil engineers and have very little knowledge of interactive 3D graphics technologies. They may select one of the above-mentioned directions as the area of the project they are required to submit. The ones who select VE design, as the subject of their project, usually have prior experience in 3D modelling and animation. Implementation is always done by using familiar 3D modelling applications (FormZ, 3D Studio max, etc.) and very basic VRML programming.

Course supportive material: Theoretical presentations are accompanied by screening of important works by Char Davies, Jeffrey Shaw and clips from relevant documentaries or films. This visual material reveals the manner in which the issues discussed are implemented in art, everyday life and communicated by the media. Experimental work developed by both authors is also presented for illustrating the issues discussed.



Views from a) B. Spyrouli's "Main Top Mast" VE and b) K. Kouris' "Mallon Dies" VE.

Coursework, projects carried out: The project that students are requested to work on has a main theme and aims at creating a VE, which visually represents a certain concept/story/process and which does not necessarily correspond to real-world situations. Examples of student work demonstrate differ-

ent approaches on creating meaningful virtual space:

- Artist B. Spyrouli designed a VE titled "Main Top Mast". She utilised visual elements and abstracted spatial characteristics from one of her previously exhibited real-space installations and adapted them to the characteristics of space within a VE.
- Architect K. Kouris designed a VE titled: "Mallon Dies" which was based on a theatrical play by S. Beckett's. He attempted to visually represent certain spatial experiences and messages, inspired by the particular play, through an interactively evolving VRML environment.

Outcome: The VE design section of this course has not yet fulfilled the original intentions and goals set by the author. This is mainly due to the fact that relevant lectures run for a limited period of time and cannot cover the majority of issues that need to be discussed for creating an adequate theoretical basis and appropriately supporting the creation of projects by students.

University of Athens (UOA) – Department of Informatics & Telecommunications

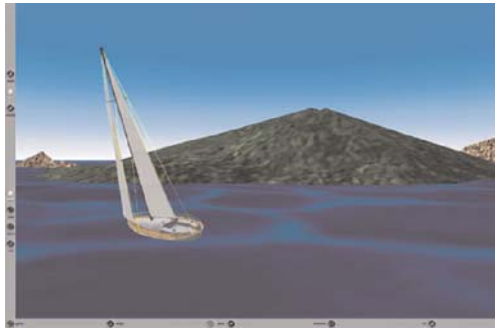
A more technologically oriented approach is adopted in the introduction of virtual reality technology as a part of the "Multimedia and hypermedia technologies" postgraduate course, in the Department of Informatics & Telecommunications – University of Athens[2]. The main focus of this course is a more detailed presentation of: most significant technologies supporting VE systems, a series of promising VR applications and available software tools. Additionally, an attempt is made to approach the process of designing VEs from a computer science perspective, while selectively presenting insights into the designer's perspective of creating a VE.

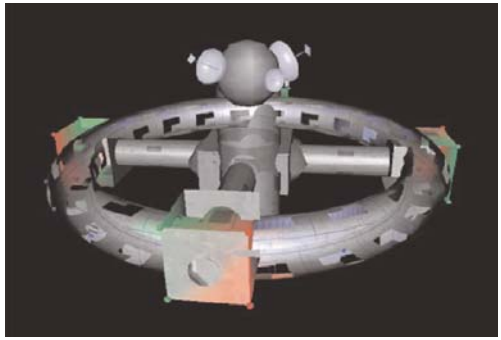
How the course fits within the overall Department's curriculum: This course can be related to other undergraduate courses regarding 3D graphics technologies in this Department. However, it follows a clearly different approach in the sense that it does not only focus on software engineering aspects but offers a more holistic introduction into VR technology.

Prior knowledge of students relevant to the course: This postgraduate course accepts students from different Departments who have relatively diverse backgrounds and consequently their prior knowledge regarding interactive 3D graphics is similarly diverse. All students who have a computer science background have the technical knowledge to follow the course in its entirety. Other students with a background on military studies or who work in secondary education (teaching physics or mathematics) often find it difficult to exploit the potential of the technology while developing their project due to a possible lack of programming skills.

The course comprises the following:

- A fairly complete presentation of most significant aspects of the technology supporting VE sys-





Views from VRML worlds representing: a) a yacht sailing in the sea (students: A. Charisi, S. Konakas), b) a space station (students: V. Stoumpos, I. Aggelis).

[2] *Associate Prof. D. Martakos is responsible for this course and the section described is taught by Dr. D. Charitos.*

tems (immersive, desktop, projection-based, etc.).

- A presentation of input-output devices (display devices, position-orientation tracking systems, 3D input devices, auditory simulation systems etc.) their supporting technologies and their significance for the interaction mode that users experience.
- A presentation of the most significant VR applications today, illustrated by relevant videos.
- A presentation of software needed for authoring VR applications and an introduction to the VRML language

All theoretical and accompanying PowerPoint visual presentations regarding the above subjects are provided on-line for students to download and read.

Coursework, projects carried out: The project that students are requested to work on mainly aims at the acquisition of VRML developing skills but also attempts to introduce students to a proper methodological process that should generally be followed while designing a VE. Students themselves select the main theme of each project, and the fact that they develop a type of environment that is of their interest usually functions as an extra motive. It is however difficult to expect students with this background to be capable of designing highly imaginative or inspirational environments. The majority of their projects represent real world situations like: houses, rooms, parks, motorways etc. However, several very impressive attempts on complex or natural environments supporting difficult to implement functionality, have also been submitted (airports, sea & yacht, space station, etc.)

Observations, outcome: This course attempts to cover, not only the technical and implementation aspects of VR technology but attempts to introduce students to certain theoretical and practical aspects of the process involved in VE design. It can be suggested that the latter goal has not yet been achieved, mainly due to the limited time available, which does not allow for a full coverage of the variety of issues that need to be presented and discussed. Moreover, the relatively large number of students (70-80) makes it very difficult to adequately tutor each individual project, while this is being designed and developed. Finally, it is very difficult to introduce theoretical concepts regarding the design of any type of environments to students with a clearly technical background.

Discussion

Teaching VE design at an undergraduate or postgraduate level is a topic in need of further research. The courses described above are relatively new, running for less than three years, and the authors are carrying out further research, drawing from newer developments as well as students' feedback, for improving their curricula. Bearing in mind the problems relating to teaching large numbers of students difficult concepts with a design studio approach, resources availability, fighting misconceptions and techno-phobia, the following discussion is hoped to contribute to VE design curricula in the near future.

VE design is considered from an architectural perspective focusing on the process of abstracting realistic environmental representation into VE representations - selecting the elements of real world space that can be adapted and integrated within VE space.

In the courses described above, the multifaceted character of Virtual Environment design is addressed from different perspectives, according to the student's background as well as the general direction of each course. Regarding the NTUA and UoA courses, VE is not the sole subject that the overall course deals with, hence there is not enough time to thoroughly analyse the theory and present the topic extensively. On the other hand, the students at UTH are complaining that the course is too hard and theoretical and they'd like more hands-on experience and studio work.

Another issue to be considered is the difficulty in

teaching VE design to computer science students, due to their lack of basic design knowledge and the different manner in which they approach the creative process in general. Computer scientists usually relate creativity with code writing and solving software engineering problems and not with the design of form and consequently space within a 3D environment. On the other hand, architects and artists express their creativity by their struggle to give shape and form to an abstract concept and to integrate it within an overall 3D context. It can be suggested therefore that computer scientists mainly want to get involved with writing code, implementation and the software engineering aspects of the VE design process while architects purely want to design the space of the VE. This observation supports the suggestions made in Bourdakis & Charitos (1999) according to which the background of architectural knowledge is an appropriate starting point for educating VE designers in general.

In terms of actual project work carried out, the main concern is the set back of real life experience and the students attempt to imitate. The sooner the students free themselves from the need to imitate real life environments the better the work that will be produced, in terms of exploiting the creative potential of VEs as a medium.

Finally, some of the difficulties that students face when following the above mentioned courses are due to the software tools for VE design, currently available. These tools differ conceptually from the 3D modelling and CAAD programs most students are used to working with, their graphical user interface is confusing and they introduce unfamiliar variables and concepts. Thus students are forced to create their models in CAD programs and to consequently export them in some VRML format variant; this process often leads to compatibility, interactivity, texturing and lighting problems.

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URL: http://www.arch.uth.gr/ Dept of Architecture Web site with the VE Design course material and student work