Trans-disciplinary Avenues in Education: Computing and Art

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Abstract. In this paper we report on an interdisciplinary course "Computing and Art" taught at the Sabanci University, Istanbul for the first time in fall of 2004. We also present research activities initiated by the course activities and continued to graduate work. The two faculty members teaching the course as well as the students are an equal mix from the visual communication design and computer science departments. The course's objective is to create interactive 3D virtual environments by multiple teams of students comprised of one computer science and one design student each. The students are challenged to develop real-time graphics software and well designed virtual spaces and/or interfaces as part of the course project. However the primary mission for both domain members is to create meaningful content that is to be implemented into a non-linear spatial structure, possessing non-linear narrative; thus necessitating content development, scenario and dialogue writing, as well as research, such as relevant social, historic, art historic, audial or scientific data, when and as needed. In this paper we present the structure of the course, as well as some of the projects and lessons learned.

1 Introduction

This paper presents our idea of preparing students to new avenues of creativity and interdisciplinary research, in a wide range of creative projects based in virtuality, such as navigable three dimensional virtual environments and task specific software to be implemented in the creation of educational tools, data visualization interfaces and the like; as well as the enablement of personal projects of artistic/creative merit as the content of a hybrid course of Computer Science and Visual Arts and Visual Communication Design taught at Sabanci University, Istanbul, Turkey. A preliminary version of this paper was presented at SIGGRAPH Educators Panel in 2005. [2]

2 Background and Objectives

In daily life we are surrounded by digital media as creator or consumer. The amount of digital information we are handling is growing with tremendous speed. Scientific data to be processed and disseminated is increasing at unprecedented rates, calling out for visualization and navigation solutions with ever growing

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urgency. For a large set of application domains the job is getting more about creating digital environments for ordinary users as well as scientists and professionals from a diverse range of backgrounds and abilities: education, entertainment, visual simulations and data visualization. Increasingly for each application domain engineers, scientist and designers have to collaborate to create environments where users, without much training, can navigate and interact with ease and fascility. Moreover virtual environments allow creators from a vast array of fields, from fine art and design to writing and music, to express themselves with an interactive visual medium like no other medium before [9]. Thus students of these fields, as well as their educators have to be aware of the workings of the technology they are using as they simultaneously seek artistic, design and narrative means of expression that are appropriate to the specific challenges as well as the advantages of the computer environment: Interactivity, the usage and navigability of the third dimension in space, the non-linear qualities of hyperlinking and the unprecedented large encyclopedic quality of the contemporary cyber realm. Similar courses are being taught at Carnegie Mellon ETC 'Building Virtual Worlds' [5] and 'Animation with Maya' [7]. The latter one focuses on creating off-line animations by small teams. The first course is similar to our approach as it focuses on the creation of Virtual Environments with a Virtual Reality concept on top of the Alice platform [6]. We take a more unrestricted approach towards technology whereby our students are recommended but not restricted to use the OpenSceneGraph (OSG) Engine [10] and any of the software/hardware tools available. For the computer scientists the goal is to improve their skills in creating virtual environments by carrying responsibility for all the technical aspects such as graphics, audio and hardware as well as bringing in their creative input, in the shape and from of problem solving where advanced rendering techniques, navigation and overall architecture of these applications is concerned. For the designer the goal is to bring their visual/audial/narrative design skills and knowledge into the creation of a collaborative virtual project. One of the overall concerns of this course is to improve the students' interdisciplinary as well as collaborative skills and bring about the ability of communication in the implementation of a joint project which is of creative/artistic as well as computer scientific merit. Yet another important objective is encouraging the students to seek novel modes and solutions towards the expression and navigability of the presented material that utilizes the advantages of the cyber realm. And yet another objective is the correct implementation of already existing solutions such as the usage of avatars, hyperlinking and the utilization of three dimensionally navigable architectures.

3 The Course

3.1 Course Preparation

On the creative front the operative idea behind the preparation of the course material was the content of the projects. We were adamant that the projects had meaning, function as well as expressive/artistic merit. To this end a special

survey of art history in relation to pre-defined visual elements, such as light, colour, illustration, typography/layout and 3 dimensional visualisation/perspective was compiled alongside of which special emphasis was put on the compilation of significant information pertaining to subjects such as narrative, navigation and non-linearity to be presented in the form of lectures throughout the initial phase of the course. We focused on the major technical issues of creating interactive virtual environments for the engineering students. The course material is prepared to give an overview on computer graphics with an emphasis on real time rendering, introduction to GPU programming, scene hierarchies, input/output devices, colour science and interactivity. Furthermore we prepared two tutorial software packages on OpenGL and magnetic position trackers with detailed comments and documentation to help students during their project work.

3.2 Structure of the Course

The course was divided into two distinct time frames: During the first ten weeks of the 14 allotted to us by the semester we subjected our students to a bombardment of visual, audial, scientific and creative subject matter: 1-) Relevant material regarding computer science and programming, such as the SIGGRAPH Emerging Technologies, Art Gallery and other submissions of the last three years to inspire and educate them. The students were expected to get fluent in OSG programming. Moreover they were asked to create test applications with pixel and vertex shaders. Shaders are becoming enablers for real-time rendering of many previously off-line rendering techniques such as Phong shading, cell shading, fluid simulation etc. Therefore we were introducing shader techniques during the course flow intensively. 2-) A survey of art/cultural history, with a slant towards the subject matter at hand, specifically 3D graphics and navigational aids. Thus the key concepts such as color, light, narrative and illustration and perspective that were mentioned above were examined from this point of view, with ample visual documentation. The operative idea behind this was to demonstrate to the students how, a diverse range of artists throughout history used these techniques in their work and how the students themselves were to implement elements such as light, color, actors/avatars and illustration in their own work in the virtual realm based upon this knowledge. Thus the students were encouraged to view phenomena such as three dimensional structures, the usage of avatars, the structuring of non-linear content not only as solutions that have their origins in the cyber age but as contemporary manifestations of a long tradition of human creative endeavor. As an example: The cyber manifestation of the avatar has its origins in the tradition of mask-acting of the renaissance [11]. It is with examples such as these that we sought to ground our students' attitude to their work firmly within the long saga of human creativity and to reach beyond the here and now of contemporary cyber applications alone. The remaining 5 weeks of the 14 in total were dedicated to in-class discussions and evaluation of the team projects, which by that point had begun to manifest themselves to a greater or lesser degree.

3.3 Student Profile

In the fall of 2004 we limited the class to twenty students, ten from each domain. For engineering students one of the main selection criteria was to have sufficient programming skills and knowledge of undergraduate level computer graphics. For design students the selection criteria was to have excelled in other design classes. For both domain students being dedicated, having organizational skills, excellent in-class communication abilities were additional criteria that were also observed. Both instructors of the course feel very strongly that the future of the fields of design as well as creativity in general will hold a lot of hybrid collaborations between computer scientists and artists/designers, if not indeed hybrid professionals and professions in these areas. Thus we made a special point in selecting team project members randomly at the end of the third week of the course, by means of an in-class lottery; so as to simulate a real life working environment, where you cannot always select your working partner; as closely as possible. This we did to ensure that the main objective of the course be fulfilled: To improve the students' interdisciplinary skills as well as collaborative abilities.

3.4 Projects

The team project, upon which the entire course is focused, is on creating a virtual environment or comparable visual/audial application where the students define and create a complete interactive project from scratch. The Figure 1 depicts stages of project development from proposal to initial implementation. We did not specify that we wanted our students to design navigable 3 dimensional environments but also left the option for task specific software applications, user interface studies, 2D as well as 3D data visualization systems, generative software and other unspecified applications and projects open. However last year, the students were free to create their own projects and in the event we found that almost all the proposals submitted to us were in fact, navigable 3D environments. Each team consisted of one design student and one engineering student, who had to come to a joint decision as to the subject matter and content of the project and then proceed to develop a story, a navigational/narrative flowchart, a non-linear storyboard or as was found to be more appropriate with immersive virtual environments an 'architectural plan'. After this initial planning stage the design team member proceeded to design the visual/audial elements of the environment/application where upon the engineering team member proceeded to implement the design into the medium, as well as keeping his/her creative input, especially where technical modifications, narrative, special visualizations techniques and navigational input was required. The teams were expected to solve the problems they encountered by means of close collaboration and class sessions, with the two instructors of the course, were used to further discuss these problems and arising situations during the implementation of the design. We had a wide spectrum of hardware and software facilities for the implementation of the projects. A typical hardware setup was an Intel Pentium 4 3.0 GHz CPU with ATI Radeon 9800 GPU and 1 GB of memory. The input/output devices were

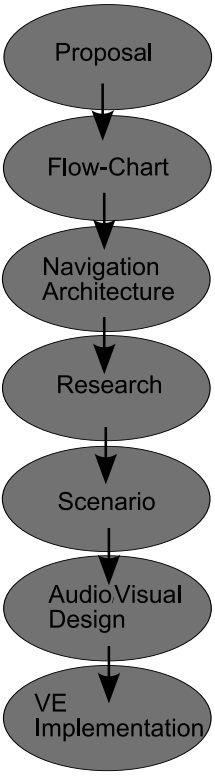

Fig. 1. Project work-flow

inertia sensors, magnetic sensors, and a passive stereo projector. Several projects were implemented with stereo option and presented in 3D. However none of the projects but one used sensor systems for user input. For modeling and sketching students were using Maya, Photoshop and After Effects software packages. As stated above the teams were free to choose any subject and technique. The resulting projects from last year can be grouped as follows: i-) Artistic expression: A couple of teams created environments to express an artistic statement, such as catastrophic worlds (Figure 2, Right) and interactive sound spaces. These projects are VE's implemented on top of OSG. In some cases 3D models are designed with Maya or 3DMax modeling tools and loaded to OSG. ii-) Interfaces: One significant project was where a team designed a device using a two degree of freedom inertia sensor (Intersense Tracker) to edit audio tracks and create new ones (Figure 2, Left). At this project students manufactured the device and wrote the 3D user interface using OpenGL. iii-) Educational environments: Most of the teams focused on creating educational 3D environments such as: The Education of Battered Women, City Guides, Origins of African Art (Figure 3). In particular the projects on educational environments focused on navigation issues. Their premise is that the end users have minimum or no

computer knowledge compounded by the overriding factor that they cannot read or write in some use cases (Figure 3, Left). Given that it is fairly easy to get lost in Virtual Environments, even for trained users, they have made a special effort to design the navigational components: 1-) Limited movement space around the environment. Users hit an invisible wall when they reach the boundaries of the accessible environment. Environments with multiple layered polygonal objects such as in the example environment of Figure 4 require careful designed collision response, as the users may get stuck between two or more layers. This feature is implemented by careful usage one of the common collision detection algorithms, Axis aligned bounding boxes, included in the OSG platform. 2-) Automated camera placement. Each Virtual Environment has story spaces, where the user is expected to participate with an interactive story be it to listen or view or to make a selection. One of the main disadvantages of 3D mediums is that users

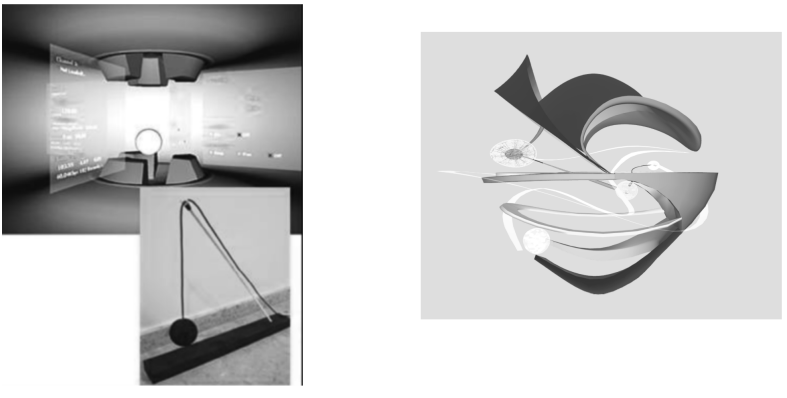

Fig. 2. Left: Interface and hardware of a sound design software. (Selcuk Sumengen, Mehmet Tolga Cirakoglu). Right: Development of a team project: Metamorphosis. A screenshot captured from real-time OSG environment. (Tugba Ozdil, Zeynep Gunel).

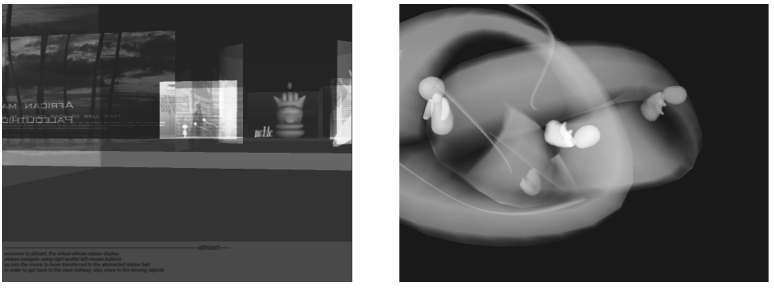

Fig. 3. Left: VE to educate battered women with no computing and reading skills. (Burcu Kinay, Nameera Ahmed). Right: VE to present a study on origins of African Art. (Funda Kivran, Yasemin Hepguler).

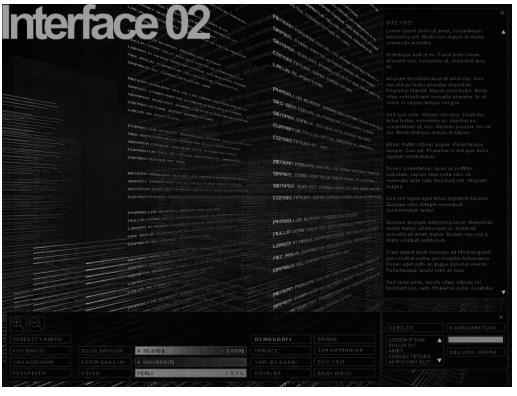

Fig. 4. Data visualization with 3D text rendering of Istanbul city map [8]

may choose an unsuitable view angle and thus cannot interact with the story correctly. To circumvent this several project groups implemented automatic camera placement routines. When a user navigates to the proximity of a story space, the camera travels automatically to the pre-designed point of view and its appropriate angle. Once the camera is placed correctly, the automatic guidance is set off and the user is free to interact with the story or continue exploring the Virtual Environment freely. The camera movement to the pre-designed end position is implemented using Bezier curves to ensure smooth camera motion. 3-) Voice/narrative. One of the premises of the presented projects is the education of the illiterate. Using voice together with animated 3D characters enables us to create a natural story telling environment either in the format of instructional voiceovers or "talking" pedagogic agents.

4 Lessons Learned

Once again, we are getting ready to teach the course in the Spring of 2006 and although the output of the last round was innovative and in most instances highly accomplished we have decided to set our students more clearly defined parameters and content for the upcoming round. One reason for this decision is the time factor: A 14 week course has a limited duration and in a situation such as this, where time is at a premium too much time during the initial weeks is spent by the team members on coming to a decision as to what the collaborative project will entail. Another factor in deciding on pre-defined content is the fact that we, as the instructors of the course, feel that the major challenges of the area in terms of content development were insufficiently addressed by the subjects that our students decided to work with: Data visualization, and especially the search for solutions towards the navigation and visualization of complex data systems [4] is one such issue and yet another is the design, programming and narrative solutions where non-linear, simultaneous and multi-linear timelines,

multiform narratives and complex storylines or story webs are concerned. Since these are some of the key challenges as well as advantages of cyber creativity, where educational as well narrative content is concerned we believe very strongly that these are issues that we shall have to implement into the syllabus by means of pre-defined projects. Where data visualizations are concerned we are further strengthened by our resolution that this is indeed an area towards which we shall be wise to direct our students: Two of the alumni of this course progressed to developed two very interesting data visualization projects: Emrah Durulan, currently a Masters' student of the VACD program at Sabanci University has been working on a GIS and Wiki/Blog inspired public map of Istanbul, which works by means of public data input and presents the structural, historic as well as personal data of the city as a layered, color coded, typographic and navigable 3D map of Istanbul. (Figure 4) Basak Alper, currently a Masters student of the Computer Science department at Sabanci University, has continued to implement the experience and insights she gained during the course CS450 to design a real-time interactive visualization system to display United States domestic air traffic data consisting over 80 million flights (1990-2004) in a dynamic geo-visualization context. She introduces a novel visualization approach integrating geographic paradigm with force directed placement techniques which will be utilized not to distribute elements of a graph, but rather to deform a 3D geographic shape. The approach focuses on two visualization techniques related to geographical data: (i) Visualization of large scale changes of a complex temporal dataset (ii) Effective use of dynamic deformations with geographic data. (Figure 5) Design of interactive 3D virtual environments is vastly different from any comparable output in other design media, such as Shockwave or Flash

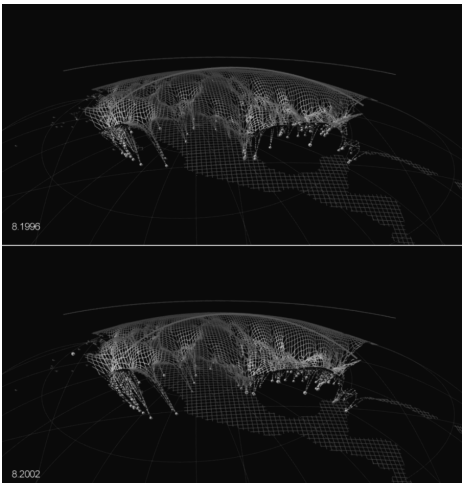

Fig. 5. Depiction of changes and trends in the data as an increase in the curvature of the deformed surface indicated with red curve. [1] (Upper image air traffic in 1996, lower in 2002).

applications. As the course progressed we realized that new ways of approaching the subject matter and handling problems had to be found at great speed. One example that can be given here is the construction of a storyboard versus a plan: Prior to teaching the course it was felt by the VACD faculty member that a non-linear storyboard and flowchart, to depict both visual cohesion and narrative, as would have been appropriate for any other non-linear interactive medium such as Shockwave or Flash, could also be implemented within the parameters of creating a virtual environment. As the course progressed this was changed into an architectural plan, viewed from above in a 3D application, since this showed the visual cohesion as well as non-linear albeit spatial transitions and the problems hanging thereon much more effectively. It is time saving as well as motivating to start with an open infrastructure to develop the virtual environments. Theoretically students may start using low level API's such as OpenGL or DirectX, but our experience shows that a higher level platform such as OpenSceneGraph is much more practical and lets them focus only on the relevant technical issues. On the other hand OSG has a steep learning curve for most of the students. To address this issue we will start using a commercial toolkit with programmable engines for animations, shaders and scene hierarchies next semester. Designing and creating a virtual environment is in its essence the creation of a cohesive world and as such it requires major production and planning: Scenario, dialogues to be written, sound to be designed and recorded (ambient as well as trigger specific and spoken dialogue), architecture and more than all of these an atmosphere, a climate. Not to put too fine a point on it: More so than any other design medium Virtual Environments need to be endowed with a "personality", be it in the shape of an avatar [3] within that environment or be it the actual environment, itself, with or without an avatar; complete with sound, narrative and visual data as well as the effects and spatial placements that pull all of these together. There is, of course, a great deal of visual design work involved but the work at hand goes much beyond that and at ideally would involve even further interdisciplinary input. With the help of our guidance, our students to date, have worked nothing less than small miracles in the creation of their environments but for the future these wider aspects and media that are of essence for the creation of viable virtual environments should also be taken into account. The first of these is the involvement of a sound specialist/design faculty member into the teaching of the course since so much of the credibility as well as usability of a 3D virtual environment does indeed hinge upon the sound employed. Beyond this the input of a specialist in narrative, especially non-linear, multiform narrative, is also urgently called for. Thus we foresee and hope that the original team of 2 instructors will rapidly extend to an extended faculty involvement - be it in the shape of specialized workshops incorporated into the syllabus or full time participation. One other valuable lesson learned is that designing a virtual environment inevitably involves research, which again would involve input of specialists from the relevant field(s). We have found that in many ways, designing a virtual environment can be likened to the production of movie and just as the production of a movie requires the efforts of vast

teams of professionals, not the least of whom are the researchers, the same would seem to apply to immersive virtual environments. We thus aim to make a concerned effort towards enlisting the input of faculty at Sabanci University, from fields other than Computer Science and Visual Communication Design in the implementation of the course in the years ahead of us.

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