3D On-line Distributed Learning Environments: An Old Concept with a New Twist

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Abstract: This paper discusses how the concept of on-line distributed learning environments is being remade with advances in affordable computing hardware, video graphics, and Internet access. The original concept from the 1970's of synchronous on-line computer mediated communications is changing in ways that can be a benefit to communities using distributed learning methods. The approach fits between course delivery that uses web-based with e-mail/bulletin-board feedback and more bandwidth intensive video conferencing technology. 3D on-line environments are appropriate to a large segment of students that still do not have broadband Internet because of cost and/or access. This paper discusses 3D on-line environments, explains the technology, and gives an example of a 3D on-line learning environment being used at the University of North Texas, Department of Technology and Cognition.

Introduction

For the past five years, 3D graphics technology has emerged that allows the creation and presentation of virtual 3D educational environments over the Internet. These same technologies have revolutionized computer games, such that the majority of games developed today utilize 3D graphics. In 2002, more than 221 million computer and video games were sold in the United States, or almost two games for every household in America. Many do not realize that the sale of video game software in the United States represents a $6.9 billion industry (Essential facts, 2003). The same technology that allows an immersive experience presented in a game context can be harnessed to present educational spaces to an ever-growing population of people that have computers with built-in 3D graphics capability.

Using Multi-User Object-Oriented environments or worlds (MOOs) for learning, training, and collaboration is nothing new to education. MOOs and MUDs have been around for over a decade now (Holmevik & Haynes, 2000). The concept of using an alternate context to provide a framework for interaction and learning was demonstrated by the MIT Media Lab during the early experimentation in MOOs. Bruckman (1992) showed that virtual meetings spaces have significant potential for training and collaboration. Since Everquest was introduced in 1999 (Sony, 2002), each year sees more on-line immersive multi-user games introduced and today these systems easily support tens of thousands of users in collaborative interactive environments; however, educational adoption of the technology has not been as successful. Everquest now supports some 400,000 plus on-line users with its on-line gaming system (Haran, 2002).

While much of the earliest pedagogy has confined the Internet to use as a virtual and expanding library (Harris, 1995), 3D on-line virtual environments as a next generational distributed learning tool are being studied to better understand its relation to existing distributed learning systems (i.e. world wide web) and the impact of immersive informational/environmental design on student and instructor interactions. The creation of a useful and integrated virtual classroom for distributed learning has long been an elusive goal. There have been numerous attempts over the years to build user interfaces to deliver realistic environments that create a context for communications, but few have reached wide use and adoption. The concept has always been a compelling one for education; however, the problem has been the availability of technology that could attain the seamless peer-to-peer interactions at a price to make its integration successful. The primary reason 3D graphical on-line systems have not been successful early in their creation for education was due in large part to the cost of technology required for student access. A computer gamer had little problem purchasing a top-end graphics card to support a new game or

system they wanted to play. Students did not necessarily have this motivation or ability to purchase the latest graphics card or systems to support an educational application. The technology has greatly improved over the last three years in that 3D on-line environments can now provide realistic, immersive learning environments that deliver required education materials while fostering learning communities. The good news is that the level of technology available on consumer grade personal computers support 3D interfaces without additional expense. No longer is the lack of a personal computer equipped with a 3D graphics card a barrier to access. The current generation of on-line 3D virtual environments has the ability to provide face-to-face interactivity as well as deliver the components provided in traditional web-based methods over thin-client access technology. (Jones, Hastings, & Christal, 2003)

Educational presentations, interactions, course delivery and more can benefit from these emerging technologies. These interactive environments have the ability to provide new and powerful means to display and convey communications among students and between their teachers. Many school age children today have grown up playing 3D games. Fifty percent of all Americans age six and older play computer and video games (Essential Facts, 2003). Children will have little problem in imagining and creating environments to present information regarding subjects for other children to explore and interact with. This paper discusses 3D on-line environments, explains the technology, and will give an example of a 3D on-line learning environment being used at the University of North Texas, Department of Technology and Cognition.

What is a 3D On-line Learning Environment

3D on-line systems are typically built on a client/server model (figure 1). The client software provides the 3D interface and communicates to a central server node/cluster that coordinates information for the user and among other users on the system. All users interacting with the collaborative environment can share information like audio chat, text chat, and movement in the world via the central server. There has been discussion of peer-to-peer designs, but the drawback is ensuring adequate security and information consistency. This is especially important in educational systems. There are some hybrid models that are worth exploring that use both client/server and peer-to-peer communications.

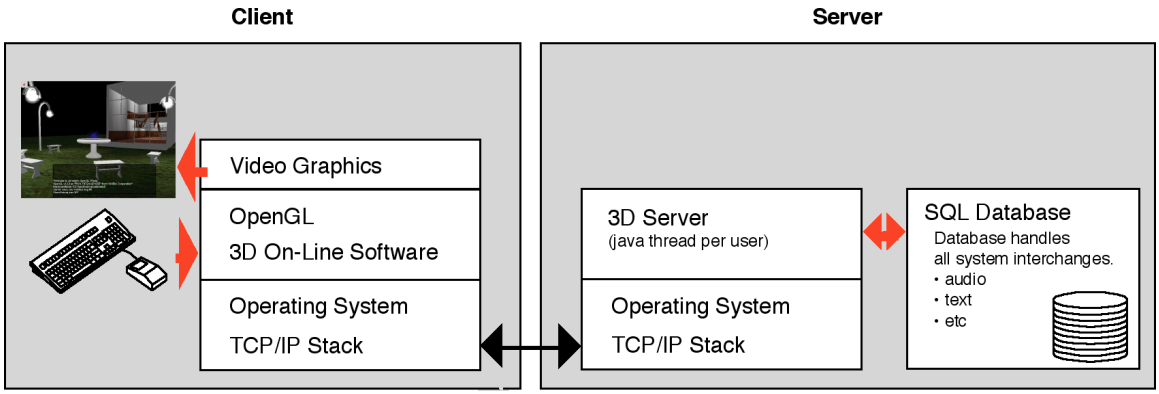

Figure 1 - Typical Client Server Model.

The client side is responsible for displaying the 3D environment and providing the user interface. A 3D environment is a presentation of objects with associated textures and is done in such a manner that a user's 2D computer display gives the representation of a 3D space. 3D objects are traditionally built using triangles or polygons to make shapes. When there is no texture associated, they appear as wire frame outlines (Figure 2). A traditional approach would need to have a 3D artist using appropriate 3D modeling software build the object. Once an object was created, an artist would be required to texture (paint) the object. Unless you have a large budget (as for a game), this approach is not sustainable for capturing and creating many digital objects, say for an educational exhibit. However, 3D scanning technology is just now beginning to become cost effective to use (Jones and Hastings, 2004). With the ability to capture both objects and their textures at the same time, there are some real interesting prospects for easier digital assets capture and management.

Figure 2 – Example of a Wireframe model (1999), that of a dinosaur. (1558 Polygons)

When the environment is built and displayed correctly, the user should intuitively understand the space as displayed (figure 3) and feel as though they are walking the halls of a building. The user has the ability using movement controls (keyboard, mouse, etc.) to move around and interact with the environment. As the user moves in the environment, the computer generates new and changing graphics in real-time to give the user feedback on their position in the environment. This gives the user a feel of motion and change of location in the space. The lack of standards for describing 3D objects on the web leads to user confusion when determining the spatial orientation of an image (Hastings, 2002). By placing these objects in a contextual 3D framework, users have known reference points for the objects. A 3D on-line educational environment can provide context about a group of images and give the viewer a richer experience.

Figure 3 - Example of a college/university environment using the Created Realities software[1]. In this example, visitors can select portraits and learn more about the scholars, by listening to the audio, reading text, reading other visitors' comments, or leaving comments of their own.

[1] http://created-realities.com

There is no single choice on how to best present or select an on-line 3D environment. Unlike the ubiquitous web browser, there are many choices on how to present the 3D environment to the visitor and no one interface is considered to be the standard to follow. As a rule-of-thumb, a 3D environment software solution should support the following basic functionality:

1) support multiple operating systems (mac, windows, linux),
2) support a flexible database,
3) support collaborative tools (text chat, audio chat, overheads, whiteboard interface),
4) support a scripting language for user interactions, and
5) provide a means to build content.

Any final choice is going to depend on the target audience, budget available, and access to programmers and graphics artists. My group has been examining, using, and programming different 3D graphic/game[2] engines over the past several years and after working with commercial game systems and various open source solutions, we settled on developing our own java-based OpenGL 3D client with a java-based server to support my concepts and research. The reason was fairly simple. The majority of game engines available are just that – programmed to support games. An educational based system needed to be more expandable, less focused on an end product, and be able to support a much lower graphics standard than what most game engines are striving to attain. The CRG system supports multiple operating systems since it is Java-based, ties directly into a MySQL or IBM DB2 database, and provides the tools to build content for research.

Benefits of 3D On-Line Learning Environments

There are many documented benefits to on-line MOOs. 3D on-line learning environments have a few additional advantages that should be pointed out. These include active immersion and engagement, ability to provide context at a lower internet bandwidth (like dialup users), and the ability to support multi-modal interactions.

Active Immersion and Engagement

Students and instructors, when interacting with each other with the 3D on-line learning environment, almost always comment that they feel more engaged. This engagement can be visually seen by participants leaning forward, focusing on the computer display during the class. As will be discussed later, we are beginning to measure these levels of engagement and participant attitudes towards the approach. An example of engagement is that an instructor can no longer simply stand in front of a class, but becomes an active discussant in the classroom. After several interviews with students and instructors, a pattern has begun to emerge that relates to being able to see the avatar of the person with whom they are communicating and not an object or a disembodied voice. Several participants have commented on the fact that they feel closer contact because they can see an avatar and thus feel obligated to pay closer attention to the discussion in order to be polite. One professor has remarked that he feels that students are better prepared because they know he is there live and might ask questions. This is a very preliminary finding and there is much more work to be done with the research.

Context at Lower Internet Bandwidth

One of the primary benefits of creating a 3D rendered environment is that it is highly bandwidth efficient. Since the learning environment is rendered and not retransmitted, the initial bandwidth is minimum and can easily support those without access to faster Internet connection. At the same time, this same approach can grow to accommodate higher-bandwidth and more multi-media objects as access to faster Internet occurs over time. Users can interact (chat, audio, e-mail, conference, overheads, etc) with other students and the instructor inside environments in real-time using a 33kbps modem connection to the Internet. Once objects and textures are transmitted and cached on the local computer, the bandwidth can be tasked for higher priority information like audio and text. This is possible because a rendered textured geometry of an object is much smaller than a high-resolution photo or video transmission. Fast performance over thin-client Internet connection is ensured by small file sizes, delivery of just in time information, and incremental rendering that only requests and then renders active visible areas on the visitor's screen. (Jones, Hastings, & Knezek, 2002). This is a very important issue for those still dealing with the Digital Divide in rural and urban settings.

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[2] A game engine is the core software components that typically handle 2D or 3D graphics rendering and may handle additional tasks such as AI, collision detection between objects, etc.

Multi-Modal Interactions

A 3D on-line learning environment can easily support multiple modes of interactions at the same time. It is not uncommon for an instructor doing a lecture to have more than one question typed in during the lecture by multiple students. Both audio and text modes are simultaneously used during the discourse. An instructor can choose a wide range of communications techniques depending on what is available to use on the system and the bandwidth available to the participants. These might include text chat, audio chat, overheads, video, AI based tutors, simulations, and many more. The class can then mix and match modes as necessary to support the best method of learning. More than one mode can be utilized to ensure that students with different learning styles or effectively reached.

University of North Texas Trials

During the 2002 and 2003 school years, the Department of Technology and Cognition has been pilot testing the Created Realities Group's (CRG) 3D graphical learning environment in an assistive manner for selected on-campus/on-line Computer Education and Cognitive Systems (CECS) courses. These included the courses on Educational Telecommunications, Survey of Educational Programming Languages, Instructional Systems Design, and Computers in the Classroom. Two sections of the course on Educational Telecommunications were offered off-campus at the UNT System Center in Dallas and for two cohorts located in Austin and Houston. The CRG system was used to allow the distant groups of students to interact and discuss the materials during one part of the course on distributed learning. The Survey of Educational Computer Languages course used the CRG software in an assistive manner. The class met every other week in-person and used several different Internet-based systems to supplement discussion between class meetings. One student, who was visually impaired, used the CRG software to participate in all the classes from home. Another student participated while on a business trip, dialing in on her laptop via a 28.8Kbps modem connection. The system also allowed the instructor to capture his presentations directly onto the server and students who could not make the scheduled meeting would login later to review the synchronized presentations (audio/text/overheads). This allowed the faculty member to deliver the course in a more natural method, and at the same time, capture the lesson with no extra work for the instructor or staff in the department. The Instructional Systems Design course used the software to provide a means of holding on-line audio discourse for the course. In semesters past, the instructor had used streaming audio that was one-way to the students in the course.

This past fall I began researching the effects of using the CRG system, since we felt that most of the glitches for use had been worked out and would not interfere with the research. Two sections of CECS 4100 (Computers in the Classroom) out of nine were chosen to use the new technology to enhance the student and instructor contact hours and to compare these sections with the rest of the course sections. Instructors and students participated in pre- and post- questionnaires and follow-up interviews for the section(s) in the current mode of offering as well as those in the 3D on-line learning environment mode. We are using the self-report comparative data, along with student evaluation and exam score date, to determine the effectiveness of the new distributed learning tool. The primary instrument to be used is the Assessing Attitudes Toward Information Technology made available by the Institute for Integration of Technology into Teaching and Learning. As of the submission of this paper, the data analysis is not yet complete for publication.

Lessons learned during 2003 trials

The lessons learned during these pilot tests were things you would expect from new technology and doing instruction over the Internet. These lessons are appropriate to just about any Internet-based technology.

Be sure to have several test sessions scheduled before actual course use so that students and instructors can work the bugs out of the system and get used to the environment. For undergraduate classes, a reward of some type (extra points) was needed to promote the students to participate in these initial test sessions. We did not see a problem with the graduate students grasping the concept and participating early and often in the test sessions. We did see one thing happen every time the system was first demonstrated to a class. The students disperse throughout the environment to explore and it is very hard to collect them back again to do the demo. This lessens with each use of the system. Because of this, we found that doing the walk-through on-line was harder than during a classroom session.

We found that planning ahead and having an alternate plan and a place to post information about what was happening before and after a session was very important. This lowered student anxiety if something unexpected happened. Being able to communicate to the students when there were problems such as the Internet connection on campus going down the night of two classes, an instructor missing a session because of a black-out in the Northeastern United States, or students having Internet problems could be dealt with in an efficient manner that did not distract from the course.

Conclusion

The future of computer graphics and representation is 3D. Education has the opportunity to positively benefit from the technology presented in this paper. The road ahead will be rough as standards emerge, change, and change again, but the potential for taking past theories of on-line communities and communications and laying them on top of these new ways of connecting and displaying information shows great promise. 3D on-line environments are not for everyone, but do fill an important niche especially when reaching individuals who fall on the low-bandwidth side of the Digital Divide.

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