Web 3D & Virtual Reality - Based Applications for Simulation and e-Learning

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Abstract

Knowledge is embedded in people and unlike information, knowledge creation occurs in a process of social interaction. As our service-based society is evolving into a knowledge-based society, there is an acute need for more effective collaboration and more effective knowledge sharing systems for use by geographically scattered people. This paper investigates the use of 3D components and standards such as Web 3D in combination with Virtual Reality paradigms for e-Learning. We are outlining the e-Learning concept in the European Union context. We are presenting a few case studies and investigating the application of Web 3D technologies to enhance e-Learning of economic concepts.

Keywords: Knowledge Transfer, e-Learning, Web 3D, X3D, Virtual Reality

1 Introduction

Web-based knowledge transfer is becoming a field of research which deserves the attention of the research community, regardless of their domain of expertise, especially because of the potential of advanced technologies such as Web 3D, virtual reality modeling languages and simulation techniques [24].

In the context of globalized communication, these technologies are becoming more stimulating through the possibility of creating collaborative spaces for simulation and training [2]. Knowledge is embedded in people and unlike information, knowledge creation occurs in a process of social interaction. As our service-based society is evolving into a knowledge-based society, there is an acute need for more effective collaboration and more effective knowledge sharing systems for use by geographically scattered people.

The starting point of this paper is the success story of the 3DRTT project (*www.3drtt.org*), a Web-based radiation therapy planning system used for simulation and training in the medical industry. We would like to transfer this type of solutions in other fields of training, such as the development of information technology systems in economics (for example in presenting a virtual space for the organization chart and the document workflow), and integration with other types of methods and technologies.

The paper is structured as follows. In Section 2 we provide a brief explanation of the e-Learning concept in the European Union context. In Section 3 we analyze the

components of Web 3D and the associated software components. Section 4 presents a few case studies and applications developed using Web 3D technologies. In Section 5 we are performing a preliminary investigation of the application of Web 3D technologies to enhance e-Learning in economics. We close the paper with a set of conclusions regarding the application of Web 3D in an e-Learning environment and future work regarding the application of 3D visualization in economics.

2 The e-Learning Concept

The e-Learning concept originated in the corporate literature of Computer Based Training Systems in the mid-1990 and is a general term used to refer to computer-enhanced learning. In the specialized literature, e-Learning designates the transfer of knowledge and education through electronic means. E-Learning involves the use of IT&C (Information Technology and Computers) paradigms, usually a physical distance between the sender and the receiver as well as teaching materials available on Intranet/Internet or on electronic supports like CD-ROMs or DVDs.

Romania as a European country has integrated IT&C in its educational system, being constrained to cope with challenges like the reform of education in a knowledge-oriented society. At the Lisbon European Council in March 2000, Heads of State and Government set an ambitious target for the European Union to become *"the most competitive and dynamic knowledge-based economy in the world capable of sustainable economic growth with more and better jobs and greater social cohesion"* by 2010 [23]. They also placed education firmly at the top of the political agenda, calling for education and training systems to be adapted to meet this challenge with the following aims:

- The implementation of the Information Society Technologies (IST) according to the European Union Framework-Program (FP6, FP7);
- The development of research, projects, and software for e-Learning;
- To promote and develop scientific research for e-Learning, educational software and Virtual Reality.

Among the elements that need to be taken into account when designing e-Learning systems are: the target group, the objective, the learning content, the didactic strategies, resources (budget, time, personnel) and most importantly the technology used to deliver the content.

Nowadays, we notice a transition to a new Web, the "*WWW space being seen more like a software platform, where the user controls and creates his own data and information, usually making them available for the others by means of collaborative instruments*"[4]. Web 2.0 is an informal name for the new generation of web applications, oriented towards social needs, focused on the separation of the relevant information from the irrelevant one and on "usability tests", as it is addressed to persons without much training in computer science, for whom the e-Learning interface should not be more complicated than the use of domestic appliances (phone, TV etc.). Web 2.0 integrates the solutions and the services of the old Web 1.5, to which it adds innovations such as: RSS, blogs, podcasts, wikis, collaborative bookmark systems, web API, web services, Ajax, Ruby-on-Rails etc [18]. As technology and knowledge evolves, more and more educational sites appear on the market [20], [21], [22], [26], and also conference supported from important companies [11].

Let's take a brief look at the e-Learning context. According to [3] as illustrated in Figure 1, the concept of Internet-based learning is broader than Web-based learning. The Web is only one of the Internet services that uses a unified document format (HTML), browsers, hypertext, and unified resource locator (URL) and is based on the HTTP protocol. The Internet is the biggest network in the world that is composed of thousands of interconnected computer networks (national, regional, commercial, and organizational). It offers many services not only Web, but also e-mail, file transfer facilities, etc. Hence, learning could be organized not only on the Web basis, but also for example, as a correspondence via e-mail. Furthermore the Internet is based not only on the HTTP protocol, but on other proprietary protocols as well.

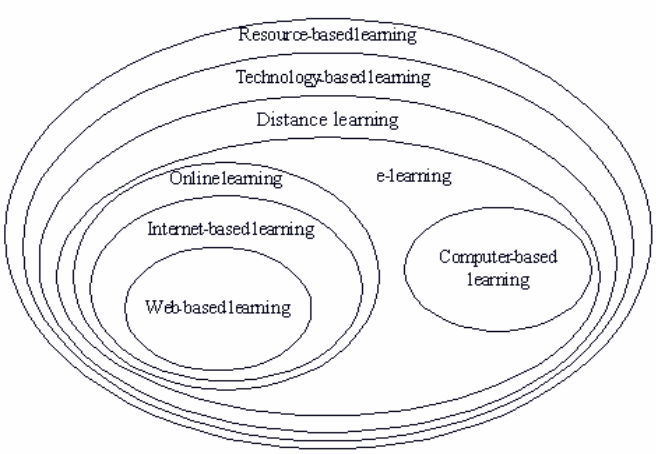

Figure 1. Subsets relationships among the group of terms [3]

Distance learning is broader than e-Learning, as it covers both non-electronic (e.g. written correspondence) and technology-based delivering of learning. Technology-based learning is delivered via any technology, so it entails distance learning, too. Resource-based learning is the broadest term because any technology could be used as a resource in the learning process, where learners are active.

2.1 The e-Learning Program

Through the initiative of e-Learning, the European Commission gained a considerable experience in encouraging cooperation, in forming networks and in exchanging students and workers among countries. Basically, e-Learning offers comfortable and efficient access to novel information and knowledge, new and efficient methods of teaching, and knowledge evaluation, as well as permanent education and formation.

Another good example for promoting e-Learning is the national educational plan presented in front of the US Congress in 2005 by the Department of Education. Its aims are: computer management in schools, online evaluation and e-Learning. "*The plan was necessary due to the fact that after a decade of technological investments in education, initiated in 1996, the indicators of scholar performance have remained unchanged until now*", underlined Susan Patrick, head of the Bureau for Educational Technology within the Department of State.

2.2 Standards for e-Learning

The standards that lie at the core of e-Learning activities are based on specifications produced and developed by experts in the field of industry and education. The main benefits of standardization for the educational system are:

- *Accessibility*; it allows usage of an e-Learning object situated in a place that is connected to the system, from any other external point without actually transferring that object. The system is based on the fundamental principle that an object created and validated becomes unique;
- *Reusability*; an object or a content created in a certain place can be utilized anywhere else on the working platform;
- *Viability*; the ability of an object to be used as many times in different contexts according to the training objectives;
- *Durability*: the objects created on the basis of specific standards remain valid throughout time regardless of the technological changes.
- *Efficiency*: the standards raise the final outcome of the training process without raising its costs along with it.

Currently there are four groups that guide the development of e-Learning standards:

1. AICC/CMI – created a guide in constructing the content of teaching units (i.e. the objects of training), communicated along with a learning management system. These standards were founded in 1988 (www.aicc.org/pages/aicc_ts.htm);
2. ADL/SCORM – defined the way in which the contents of the teaching units can interact within other systems (www.adlnet.gov);
3. IMS - developed a guide to help labeling, testing and packing the content of the meta-data (www.imsglobal.org);
4. ARIADNE – was created by a group of universities within the European Community and Switzerland. ARIADNE is not exactly a training system, but an environment in which the development, the management and the usage of educational materials with various contents is facilitated (www.ariadne-eu.org).

3 Three-Dimensional (3D) Content Online: Web 3D

Real opportunities exist for the development of novel educational and training materials, particularly for science applications where 3D visualization is critical for understanding concepts. A 3D virtual space brings advantages such as increased motivation on behalf of the student and increased efficiency in explaining difficult concepts. There are fields, such as medicine, where the Web 3D-based applications have proved their utility already [6],[7],[8],[9].

Developing applications based on the 3D paradigm in the e-Learning context implies using different types of software tools and frameworks that, considering their functionality, can be categorized as follows:

- Traditional Web-based programming languages such as HTML, XML, JSP, ASP, PHP;
- Specific Web 3D standards and programming languages: X3D [1];
- 3D content development tools [14],[15],[16] such as Maya, 3D Studio Max, SolidWorks;

- Web 3D authoring tools and plug-ins such as X3D Edit; Flux Studio, Bit Management.

In what follows we are taking a detail look into each of the above components.

3.1 Traditional Web-Based Programming Languages

Probably not much to say here, just that the existing languages like HTML and the more robust XML (eXtended Markup Language) will continue to find uses in the implementation of 3D Web-based sites. Merging text, animation, sound and 3D content can be done using these standards. Java Server Pages (JSP), Active Server Pages (ASP) as well as PHP can be used to provide the necessary functionality on different architectures from client-server to n-tire.

3.2 Web 3D Standards and Programming Languages

X3D is an ISO standard with an open architecture and a rich range of capabilities for real-time graphics processing that is employed in a wide array of domains and user applications. A successor to VRML, X3D is being developed by the Web 3D Consortium as a refined standard [10].

3.3 Content Development Tools (3D)

Maya™ is one of the world's leading innovators of 3D graphics modeling technology. In 2003, the company was awarded an Oscar for technical achievement from the Academy of Motion Picture Arts and Sciences for its development of Maya software, its professional 3D animation and effects package. The Maya software was employed in the making of movies like Spider-Man®, Star Wars: Attack of the Clones®, The Lord of the Rings™. Maya allows development of polygonal models, NURBS (Non-UnifoRm B-Spline) modeling, as well as the creation of materials and lighting.

Another framework SolidWorks™, allows development of 3D models and rapid prototyping of 3D shapes from 2D CAD drawings. The newest component 3D Instant Website (Figure 2) provides a step forward in 3D design communication via the web, allowing users to publish the designs instantly and to communicate with an entire work team – other designers, manufacturing staff, marketing management, purchasing agents, suppliers, and customers [16]. Users can view, rotate, zoom, and pan these models without having to buy CAD software or install special viewers.

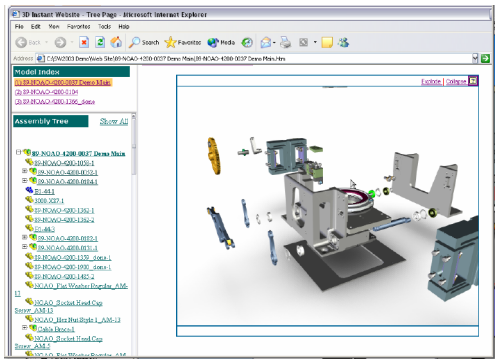

Figure 2. SolidWorks in conjunction with the Web

3.4 Web 3D Authoring Tools and Plug-ins

The X3D based web pages need a special plug-in to be installed in the web browser. This plug-in is an X3D content player. Several companies offer X3D player implementations for free or on a license-basis

The Bitmanagement Contact X3D Player [12] is one of the best implementations (based on the number of software "bugs") that we have found so far on the market (screenshot in Figure 3). Another X3D player "Flux Player" was developed by Media Machines [13]. The company develops also an X3D authoring tool called Flux Studio.

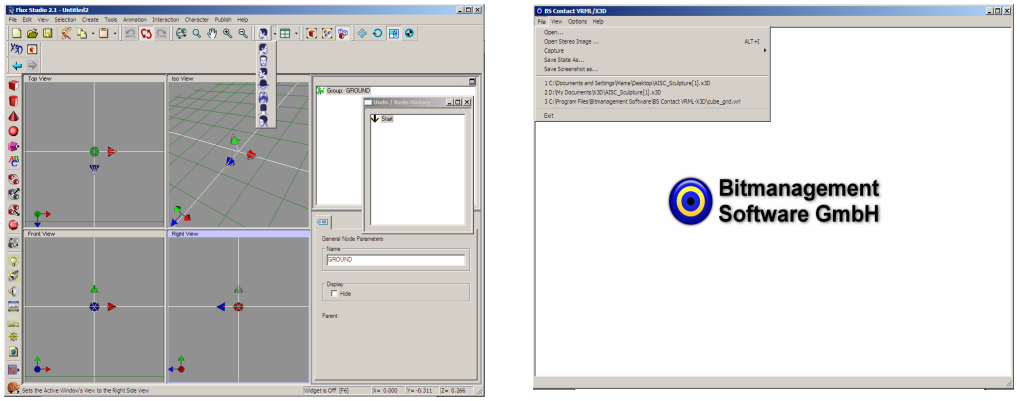

Figure 3. Flux Studio (left), Bitmanagement Software (right) X3D Players

4 Web 3D - Two Case Studies

In what follows we are presenting two uses of Web 3D to enhance understanding of concepts. We would like to mention that even though the Virtual Reality Modeling Language (VRML) becomes obsolete and is being replaced by X3D, some of the work on the cases below has started in VRML and was slowly transitioned to X3D.

4.1 Neural Network

The case study of the application *Pruning a neural network,* author Finn Årup Nielsen [17], exemplifies the use of the Web 3D standard, X3D.Reducing a neural network's complexity improves the ability of the network to be applied to future examples. Like an over fitted regression function, neural networks may miss their target because of the excessive degrees of freedom stored up in unnecessary parameters. Over the past decade, the subject of pruning networks has produced non-statistical algorithms like *Skeletonization*, *Optimal Brain Damage*, and *Optimal Brain Surgery* as methods to remove connections with the least salience. The methods proposed in this model use neural network method to remove multiple parameters in the model when no significant difference exists.

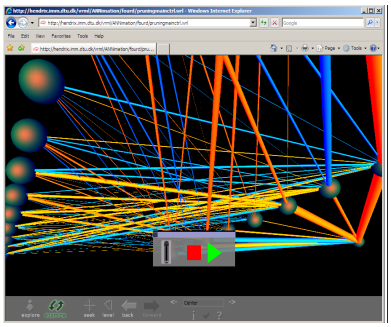

Figure 4. View the model with Flux Player

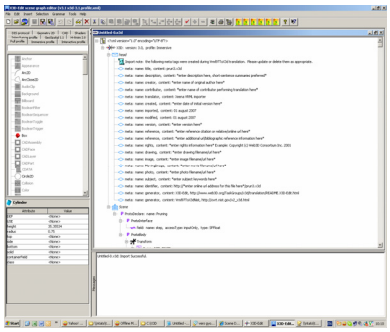

Figure 5. Importing the VRML code in

The application includes the VRML code describing the 3D model of a neuronal network and allows viewing using an authoring tool. In order to compare features, Flux Player, Figure 4, as well as BS Contact Software Management, Figure 6, were used.

While testing the application, we imported the VRML source code, obtained by using the author's consent, into X3D using the X3D editor (see Figure 6 and 7).

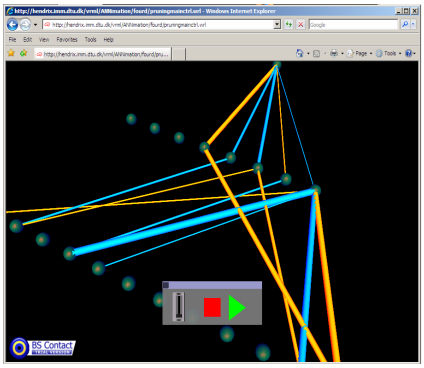

Figure 6. Used cod X3D with BS Contact Player

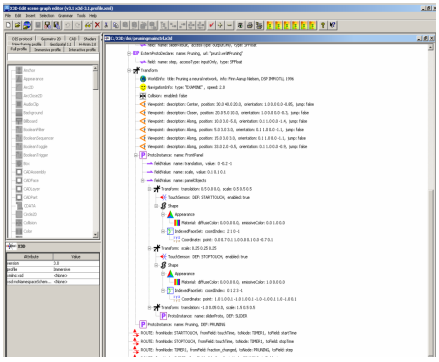

Figure 7. X3D imported rules with success

4.2 Radiation Therapy Training in 3D

The VRML has been employed to provide the visual web-based interface in the past. The European Institute of Telesurgery has proposed a 3D anatomical structure visualization and surgical planning system that allows manipulation and interaction on virtual organs extracted from CT-scan or MRI data [8].

With the advent of the X3D standard and its extended functionality, the Internet-Based systems for simulation gained momentum. The 3DRTT simulator implementation [25] takes advantage of two technologies, Java and X3D. Figure 8 illustrates a snapshot of the virtual room (denoted 3D Radiation Therapy Treatment - 3DRTT) which models the real environment (treatment room).

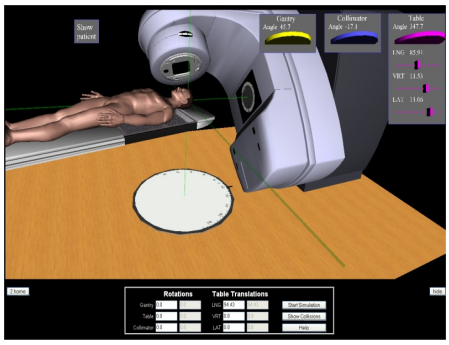

Figure 8.A Snapshot of the Virtual Room

The simulator provides an intuitive floating graphical user interface (GUI) for controlling the angles and locations of the machine's parts. The user may rearrange the GUI components to avoid occlusions of important objects. Volumetric slides and scrolls keep controlling operations simple and naturally fit in the 3D scene.

The Web-based simulator has the ability to precisely detect/predict a possible collision between all hardware components for a given patient eliminating the need for backup plans, and saving planning time. In addition, 3DRTT enables the planner to explore different and unconventional gantry-couch-collimator combinations for treatment that may give rise to better quality treatment plans.

5 Web 3D in Economics: 3D for Financial Markets and Forecasting

The promise of computers has always been their ability to extend the capacity of the human mental processes. Nowhere is that promise more fully achieved than in neural networks and in no field are the implications of greater economic significance than finance and the application of neural networks in the financial world. Distinct methodologies solve different problems encountered in the financial world [5].

Asset and portfolio managers, market makers, stock traders, market advisers deal with an overwhelming amount of information on a hourly basis. The financial market analysts and traders need better tools for technical analysis. Real-time data of interest consists of 10's to 100's of symbols that should be followed in time and in relationship with other important market factors. Large quantities of numerical data are virtually impossible to understand quickly and accurately with existing tools.

Until very recently the 3D was exclusively used by professionals in other fields (e.g. movie makers, web designers, etc.). It would be interesting for money traders or stock market advisers to use 3D graphics easily without spending much time learning the details of the application. A first step in this direction was taken by the ***3DStock software*** (illustrated in Figure 9 and 10) [19].

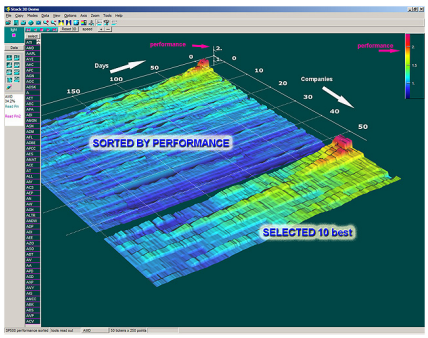

Figure 9. 3D rep. of Financial historical data

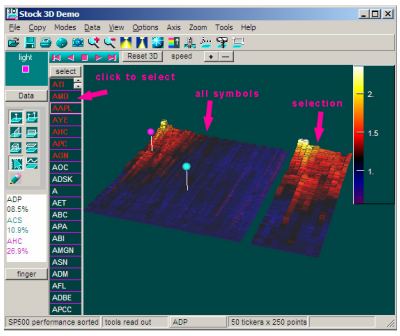

Figure 10. Financial historical market data

Each company is visualized in 3D as a tape stretching along the time coordinate. There are 2 surfaces available, one is the full data loaded and the second is the default selection of the 10 best performing symbols. The selection can be made with left side list of all symbols loaded. The height of the tape is proportional to the normalized performance of the symbol. For easy perception, the performance of the symbols is colored with a distinct color palette. The advantage of the 3D visualization is that you can immediately evaluate the performance of multiple symbols at a glance. In the example above there are 50 companies on the main surface and 10 companies in the selection surface. According to the palette, best performing tickers are colored as red, while medium as yellow, worst as dark blue.

Conclusions

3D Virtual Reality, software tools and associated Web technologies are mature enough to be used in conjunction with advanced e-Learning systems. 3D based content can enhance communication of ideas and concepts and stimulate the interest of students. We have provided a brief review of the main software components required to develop a 3D e-Learning environment.

We have explored two applications of the new X3D standard in neural networks and medical training. Then we focused our attention on the application of 3D technology in the economics domain.

Our near future efforts are directed towards the development of a Web 3D platform for presenting core concepts and phenomena related to economics.

References

Books:

[1] Don Brutzman, Leonard Daly: (2007): "*X3D: Extensible 3D Graphics for Web Authors*", Morgan Kaufmann Publishers, 2007

Conference Proceedings:

[2] Vlada, M., Tugui, Al.,(2006): "*Information Society Technologies - The four waves of information technologies*", ICVL 2006, October 27-29, pp. 69-82

[3] Anohina A.,(2005): " *Analysis of the terminology used in the field of virtual learning", Educational Technology & Society*

[4] Stefan V., (2007):"*La contribution des systemes informatique d'interface dans la création d'un espace collaboratif dans l'UE élargie* ", EUCONF 2007 18-21 April, Rijeka, Croatia (http://www.efri.hr/english/prikaz.asp?txt_id=4569)
[5] Firescu V., Stefan V., (2007): "*Instruments financiers et marchés financiers",*55ème Congrès AIELF 2007-Varsovie, 21-24 May
[6] Hamza-Lup F.G., Sopin Ivan and Zeidan Omar: (2007): "*Towards 3D Web-based Simulation and Training Systems for Radiation Oncology*", ADVANCE Magazine for Imaging and Oncology Administrators, Vol.17 (7), July 2007.
[7] Lau, R., Li, F., Kunii, T., Guo, B., Zhang, B., Magnenat-Thalmann, N., Kshirsagar, S., Thalman, D., Gutierrez, M., (2003): "*Emerging Web Graphics Standards and Technologie"* — Web Graphics Tutorial. In *Computer Graphics and Applications*, vol. 23, pp. 2-11.
[8] K. Chirstophe, S. Luc, M. Jacques, (2002): "*PACS-based interface for 3D anatomical structure visualization and surgical planning*," Proc. SPIE - Medical Imaging 2002 Visualization, Image-Guided Procedures and Display, vol. 4681, pp. 17-24

Internet Sources (last access date August 14, 2007)**:**
[9] http://www.cs.armstrong.edu/felix/html/research.html
[10] http://www.web3d.org
[11] http://education.siggraph.org/committee
[12] http://www.bitmanagement.com
[13] http://www.mediamachines.com
[14] http://usa.autodesk.com/adsk/servlet/index?siteID=123112&id=7635018
[15] http://www.the3dstudio.com/product_details.aspx?id_product=3393
[16] http://www.solidworks.com
[17] http://hendrix.imm.dtu.dk/vrml/ANNimation/ANNimation.html
[18] http://en.wikipedia.org/wiki/Web_2
[19] http://www.scienceGL.com
[20] http://www.timsoft.ro:80/index.php?pagina=resurse2
[21] http://www.academiaonline.ro/
[22] http://www.elearning.ro
[23] http://www.europarl.europa.eu/summits/lis1_en.htm

Technical Reports:
[24] Hamza-Lup F.G., (2004): "*A Less Intrusive System Monitoring Scheme for Distributed Virtual Environments*", Computer Science, University of Central Florida.
[25] 3DRTT Project: http://www.3drtt.org/
[26] HaptEK16 Project: http://cs.armstrong.edu/felix/projects/HaptEK16/index.html