

DISS 880 - Preliminary Proposal:
Virtual Reality on the Internet

by

Ronald G. Wolak
wolakron@nova.edu

A paper submitted in partial fulfillment of the requirements
for DISS 880

School of Computer and Information Sciences
Nova Southeastern University

October 2000

An Abstract of a Paper Submitted to Nova Southeastern University in Partial Fulfillment
of the Requirements for DISS 880

DISS 880 - Preliminary Proposal:
Virtual Reality on the Internet

by
Ronald G. Wolak

October 2000

Virtual reality applications are used on the Internet to create the illusion of reality. Their objective is to provide as realistic an environment for the user as possible. They are often applied in the areas of entertainment, training, medicine, manufacturing, virtual communities, and e-commerce. As VR applications become more common on the Internet, Web designers are presented with the problem of understanding how and in which areas VR applications are best applied. In response to this problem and to partially fulfill the requirements of DISS – Multimedia Systems, this preliminary project proposal was submitted. The goal of the proposed project was to identify which VR technologies and applications were currently in use and to find answers to related questions. In the following pages, the project proposal paper included the first three chapters of the project paper. The first chapter covered the project's problem statement and goal, final deliverable, relevance, barriers and issues, plan and approach, product development process, justification, and milestones. The second chapter provided a review of the literature relevant to the problem. The third chapter described the research methods and online tools and resources that would be employed in completing the project. In addition, the criteria used to develop the multimedia product and its marketing plan were discussed. In conclusion, a discussion of anticipated benefits and projected outcomes of the project report were presented.

Table of Contents

Abstract ii

Chapters

1. Introduction 1

- Problem Statement and Goal 1
- Final Deliverable 2
- Relevance 2
- Barriers and Issues 2
- Plan and Approach 3
- Product Development Process 4
- Justification 4
- Milestones 5
- Summary 5

2. Review of Literature 6

- Bandwidth and QoS Considerations 6
- Panoramic Images and Video 7
- Proprietary VR 7
- Usability Testing 8
- VRML 9

3. Methodology 11

- Research Methods Employed 11
- Online Tools and Resources 11
- Product Criteria 12
- Marketing Plan 12

Expectations 14

Annotated Bibliography 15

Reference List 26

Chapter 1

Introduction

This preliminary proposal is submitted to satisfy the initial requirements of DISS 880 – Multimedia Systems. The following introduction describes the problem to be investigated, the goal to be achieved, and the final deliverable of the project. In addition, the introduction provides an analysis of the relevance of the research and the potential barriers and issues expected during the completion of the project paper. Finally, the introduction details the plan and approach of the project, justifies the legitimacy of the proposed solution, and provides a timeline of project milestones.

Problem Statement and Goal

Virtual reality (VR) applications are used on the Internet to create the illusion of reality. Their objective is to provide as realistic an environment for the user as possible (Tannenbaum, 1998). They are often applied in the areas of entertainment, training, medicine, manufacturing, virtual communities, and e-commerce. As VR applications become more common on the Internet, Web designers are presented with the problem of understanding how and in which areas VR applications are best applied (Powell, 1999).

The annotated bibliography at the end of this paper is the result of an investigation into this problem. The goal of that investigation was to identify which VR technologies and applications were currently in use and also to find answers to the following related questions:

- How widespread is the use of VR technology on the Internet?
- How successful are current VR applications?
- What design challenges do they present?

- Which applications are effective and usable?
- In which areas are VR applications best applied?

In addition, the research focused on the implementation, positive and negative effects, and trends of the use of VR on the Internet.

Final Deliverable

The final deliverable of the project will be a ten-minute interactive multimedia presentation titled *Virtual Reality on the Internet*. The presentation will be developed and viewed using Microsoft PowerPoint 2000. The content of the multimedia product will introduce current Internet VR technologies: Virtual reality modeling language (VRML), panoramic images, and proprietary VR. In addition, the presentation will show examples of applications developed with each of these technologies. The presentation could be marketed as an interactive training aid for novice Web developers seeking to understand the use and proper application of virtual reality on the Internet.

Relevance

This research is relevant to the study of multimedia systems because of the increasing use of VR applications and the enhanced experience that VR provides viewers of multimedia productions delivered over the Internet (Regan, 1998). The research is significant because a better understanding of the current state of VR applications will benefit Web developers as they apply the technology.

Barriers and Issues

The primary barrier to the successful completion of this project is the vast quantity of research material related to VR technologies on the Internet. This material

must be gathered, compiled, filtered, and evaluated to determine its appropriateness to the project.

Successful project completion is also complicated by the requirement for the multimedia product to run smoothly on a variety of personal computers and Internet connection speeds. Incompatibilities between the various VR application drivers, along with PowerPoint imperfections also add to the challenge.

Plan and Approach

The proposed project report will be a descriptive study formatted in five chapters. The first three chapters will be substantially the same as the corresponding chapters of this project proposal. The first chapter covers the project's problem statement and goal, final deliverable, relevance, barriers and issues, plan and approach, product development process, justification, and milestones. The second chapter provides a review of the literature relevant to the problem. The third chapter describes the research methods and online tools and resources that will be employed in completing the project. In addition, the criteria used to develop the multimedia product and its marketing plan is discussed. Included is a list of desirable product features, along with a description of the processes use to develop and validate that list.

The fourth chapter of the proposed project report will document the product development cycle. Topics to be included are:

- Development process
- Problems encountered
- Lessons learned
- Authoring system and rationale for selection
- Product evaluations
- Evaluation criteria

- Test development, subject selection, and summary of results

In the fifth chapter, recommendations for improving the product are discussed along with a summary of the entire project paper.

Product Development Process

The multimedia product will be developed and tested using classic multimedia project management techniques (England & Finney, 1999). The first step of that process is to develop a list items the product must accomplish in order to solve the problem (i.e. project objectives). This list is discussed in chapter three of this proposal.

The next steps are to define the presentation's target audience, hardware and software requirements, and product features. These are also defined in chapter three. Actual development of the product is the next step and is followed by the test and evaluation phase. Finally, the marketing plan for the product is developed and executed.

Justification

The multimedia product delivered at the end of this project is a legitimate solution to the problem of helping Web developers better understand the application of VR technology. Its legitimacy stems from the ability of such presentations to effectively instruct through the combination of multiple multimedia elements into one integrated, coordinated, and synchronized work (McKeown, Feiner, Mukesh, & Chang, 1998). Since each of the multimedia elements of the presentation will deliver information about the same topic, the individual elements are not generated in isolation and are therefore a more effective instructional medium.

Milestones

The scope of the proposed project report is manageable and lends itself to investigation within the given time period. The following is a summary of the milestones for the project along with significant dates. The first milestone, the submission of the project proposal, will be completed and submitted for review on or before October 20, 2000. After approval of the project proposal, the completion of chapter four, the final deliverable, and chapter five are the last milestones before submission of the final project report and the final deliverable. Chapter four and the final deliverable are scheduled to be completed by January 13, 2000 and chapter five prior to January 20, 2000. After extensive proofreading and testing, the project report and final deliverable will be submitted on January 21, 2000.

Summary

In summary, the section above introduced the problem to be investigated, the goal to be achieved, and the final deliverable of the project. Also included were an analysis of the relevance of the research and the potential barriers and issues expected during the completion of the project paper. Finally, the introduction detailed the plan and approach of the project, justified the legitimacy of the proposed solution, and provided a timeline of project milestones. In the next chapter, this proposal provides a review of literature relevant to the problem of understanding how and in which areas VR applications are best applied.

Chapter 2

Review of the Literature

The literature review that follows is organized by subject heading. Those subjects include: bandwidth and QoS considerations, panoramic images and video, proprietary VR, usability testing, and VRML. A review of the literature pertinent to these subjects is critical to achieving the project's goal to identify which VR technologies and applications were currently in use and also to find answers to related questions. In addition to subjects directly related to VR technology, usability testing, and bandwidth and QoS considerations are covered due to their importance in delivering a high quality multimedia product.

Bandwidth and QoS Considerations

Vernick, Venkatramani, & Chiueh

In a related journal, Vernick, Venkatramani, & Chiueh discuss bandwidth and QoS considerations (Vernick, Venkatramani, & Chiueh, 1996). To successfully distribute a networked version of a multimedia presentation, new issues need to be addressed. Two of these are the need for large aggregate I/O bandwidth and the guarantee of real-time performance to ensure reliable and synchronized playback at the client.

Currently the bandwidth and QoS requirements to deploy the presentation "as is" are not available over the Internet. These limitations can be addressed by either stripping the presentation of most of its multimedia content or by delivering the presentation in a manner that compensates for the limitations of the Internet. The latter is the most acceptable. Therefore the deliverable will be a stand-alone presentation delivered on a compact disc using the standard PowerPoint viewer.

Panoramic Images and Video

Powell

Panoramic images are often described as “poor man’s” VR. In a recent article, Powell discussed how faking the real world with panoramic images is sometimes better than trying to model it (Powell, 1999). Many times a full screen picture of a 3D object will suffice. Panoramic images can be used to create the illusion that a user is in 360-degree rotation. When the capability to click on the image and zoom in and out is added, the image seems more like virtual reality than VRML.

Examples of this technology include IPIX – PhotoBubbles, QuickTime VR, QuickStitch, and RealPlayer VR Video. Powell added to the project by categorizing the various types of VR applications to be investigated and presented.

Sellers

In a related article, Sellers described the continued growth of Apple’s QuickTime VR technology. Recently, Corbis began offering the first 360-degree panoramic catalog of stock photos in the industry (Sellers, 2000). The images are typically used for multimedia applications presented at trade shows and in retail displays. The panoramics are viewed using the QuickTime VR engine. Sellers contributed to the project by pointing out one possible source of content to include in the final deliverable.

Proprietary VR

Bourdakis

Bourdakis compared proprietary VR systems with VRML applications in another article. The paper discussed the advantages of VRML compared with proprietary VR

systems (Bourdakis, 1997). VRML systems tended to be more expensive and lacked a number of advanced features such as model creation tools.

In addition, many VRML applications required a new hardware/software platform for development. The paper contributed to the project by pointing out differences between the two technologies.

Usability Testing

Usability testing focuses on whether a user interface is easy to learn, satisfying to use, and has the functionality that users want (Branaghan, 1999). Its goal is to show the designer how a product might be improved. In traditional usability tests, the tester observes users as they use a product to perform tasks (e.g. locate information on the Internet). During the testing, the evaluator collects both quantitative and qualitative data describing user performance and satisfaction. Usability testing also provides the researcher the opportunity to “pick the user’s brain” by asking follow-up questions.

Jordan

In a recent text, Jordan described how to conduct a usability evaluation (Jordan, 1998). According to Jordan, evaluating an existing product has advantages. Products that have been on the market for a while have an experienced user base. These users are able to report on the positive and negative aspects of using a product in its real context of use.

Jordan continued with a description of the two types of data that can be elicited from a usability evaluation: quantitative data and qualitative data. Quantitative data is useful in situations where a design decision has to be made and a number of possible solutions are being considered. Qualitative data is also useful for a number of reasons. First, it can be used as an approximation of quantitative data when making a "first pass"

at addressing an issue. Next and more important, qualitative data can be used to diagnose usability faults and prescribe solutions.

Rubin

In another text, Rubin defines usability testing as a process that employs participants who are representative of the target population to evaluate the degree to which a product meets specific usability criteria (Rubin, 1994). Rubin's text emphasized the more informal, less complex testing methods designed for quick turnaround of results in industrial product development environments.

Rubin described the test plan as the foundation for the entire test. It addresses, the how, when, where, who, why, and what of a usability test. The test plan serves as the blueprint for the test. It is also the main communication vehicle between the developer, test monitor, and the rest of the development team.

VRML

VRML is a 3-D graphics language used on the Web. VRML pages can be viewed and rotated. In related works, Lawton, Li, Lien, Chiu, & Yu, and Matsuba & Roehl contributed to the project as follows:

Lawton

In an IEEE journal article, Lawton described a number of VRML-based projects recently completed for clients that included Platinum technologies and CNN Interactive. The application developed for Platinum was a 3D network visualization that allowed nontechnical users to easily navigate through and diagnose problems with a network. The CCN project used a large 3D polygonal object mapped with a high-resolution image of a hurricane.

One roadblock encountered by the author during the course of each of these projects was the lack of one standard VRML browser. Key to the success of future VRML applications is this standard. The author's real life examples of VRML applications on the Internet aid in the development of the final deliverable by pointing out a number of possible roadblocks.

Li, Lien, Chiu, & Yu

In another VRML related article, Li, Lien, Chiu, & Yu investigated the problem of navigating 3D landscapes with 2D user input devices (Li, Lien, Chiu, & Yu). Their paper proposed an alternative navigation metaphor in which users specify locations of interest on a 2D-layout map and the system automatically generates an animated guided tour in 3D.

The system was implemented using Java and a common VRML browser interface. Also employed were auto-navigation techniques in which several efficient path-planning algorithms were used. The paper benefits the research topic by illustrating an effective technique to improve the usability of browser-based virtual reality.

Matsuba & Roehl

In a recent journal article, Matsuba & Roehl described the development of the VRML Dream Project (a live performance of Shakespeare's A Midsummer Nights Dream) (Matsuba & Roehl, 1999). VRML Dream was the first live, streaming, VRML entertainment project with a running time of greater than two minutes. The production is relevant to the project because it proved that streaming both motion and voice data over standard Internet connections was possible.

Chapter 3

Methodology

Research Type

The project paper will be a research-based descriptive study. The key outcome of the investigation will be to identify which VR technologies and applications are currently in use and to answer questions related to their effectiveness. In addition, the results of the study will be formatted into a ten-minute interactive multimedia presentation titled *Virtual Reality on the Internet*.

Research Methods Employed

The primary research method to be employed throughout the course of this project will be browser-based Internet searches. The literature reviewed will include textbooks, white papers, Web site reviews, trade journals, and magazine articles referenced by a selected set of online resources. Relevant texts will be located, ordered, and delivered using the Amazon.com Internet site. The full text articles from trade journals, magazines, and white papers will be located and subsequently downloaded from a collection of online resources.

Online Tools and Resources

A variety of online agent technology resources will be used to locate and download literature relevant to the goal of the project. These resources will include ACM Search (www.acm.org/dl/search.html), Electric Library (www.elibrary.com), Gartner Group (www.gartner.com), and ProQuest Direct (proquest.umi.com). Perhaps the most powerful search tool to be employed during the course of the project will be the intelligent search agent, Copernic 2000.

Copernic 2000 is a well-documented freeware search agent. It uses predefined channel sets, which allows researchers to target inquiries to all major Web search engines, search for relevant text in newsgroups, and access popular e-mail directories to find people (Copernic, 2000). Copernic conducts fast, multithreaded, full Boolean searches with progress displays and customizable search depth. Once results are compiled, Copernic displays returns (including name, location, and introductory text) in a right-click-enhanced list box sorted by relevance.

Product Criteria

The multimedia product that will be the final deliverable of the project must accomplish a number of tasks in order to solve the problem. The product must be interactive, use multiple media types, interest the target audience composed of novice Web developers, last about ten minutes, run on an Internet Explorer-connected Windows multimedia PC purchased within the last 18 months, and thoroughly explore the use of VR on the Internet.

The above criteria were developed using the minimum requirements set forth in the DISS 880 course syllabus along with the realization that PCs older than 18 months would not be representative of computers typically used by Web developers. The criteria was validated by a survey of minimum requirements for other multimedia teaching aids along with consideration for Moore's law (i.e. PCs become twice as powerful every 18 months) (Silverman, 1998).

Marketing Plan

Once developed, two ways in which the multimedia product could be marketed are through corporate sponsorship and a product Web site (Bayne, 1997). Corporate

sponsorship from companies whose products are featured in the presentation would be the first step in funding a more comprehensive marketing strategy. An attractive product Web site would be among those strategies and could be positioned as one of the top ten search hits through the use of Web promotion tools such as Siteadd.com.

Expectations

It is expected that the multimedia presentation that will result from the completion of this project will in some small part help introduce novice Web developers to the use and benefit of VR technologies and applications on the Internet. However, time and budget constraints will limit the depth of the presentation, extent of its testing, and the reach of its marketing.

Annotated Bibliography

The annotated citations that follow are listed in alphabetical order by author. Each citation consists of a reference in bold type followed by an annotation. The annotation briefly describes the work along with its relationship to the problem and goal being researched.

Bayne, K. (1997). *Internet Marketing Plan*. New York: John Wiley & Sons, Inc.

The author, Kim Bayne is a manager at wolfBayne Communications. She specializes in strategic and tactical media relations and Internet marketing. Her book provides a comprehensive framework for producing and executing an Internet marketing plan.

In addition, the book supplies step-by-step procedures to establish, implement, and manage a corporate Website. The book adds to the research topic by suggesting possible methods to market the final deliverable once it is developed.

Broll, W. (1997, March1-5). *Distributed virtual reality for everyone - A framework for networked VR on the Internet*. Paper presented at the IEEE Virtual Reality Annual International Symposium (VRAIS '97), Albuquerque, New Mexico.

The author, Wolfgang Broll, is a researcher at the German National Research Centre for Information Technology in Sankt Augustin, Germany. The paper described a communication infrastructure able to support distributed virtual environments over the Internet. In addition, the author demonstrated mechanisms to support user cooperation and the composition of large meta-worlds.

General problems addressed in the research were keeping shared world's consistent, scalable network protocols able to support a large number of users, and the composition of large-scale subdivided worlds. Future research proposed in the paper included the ability to support consistency and interactivity between users with low bandwidth connections. The paper adds to the research topic by introducing network architectures capable of supporting multi-user virtual environments on the Internet.

Cibelli, M., Costagliola, G., Polese, G., & Tortora, G. (1999, September 27-29). *A virtual reality environment for Web browsing*. Paper presented at the IEEE International Conference on Image Analysis and Processing.

The authors, researchers at the University of Salerno, Italy, presented a method to map 2D Internet space in virtual worlds using predefined metaphors. The primary difference

between their proposed system and current VR-Web-Browsers was its ability to map both site content and structure into the VR metaphor. Web elements are first mapped within a virtual world metaphor, and then a VR-Builder creates VRML sources based upon the virtual representation.

The VR-Spider prototype described in the paper was developed using Java and VRML. The scope of the prototype was to assist naive Internet users in exploring Web sites through the use of friendly metaphors. In the future, the authors intend to further this research with the integration of MPEG 7 technology into the prototype. In addition, the VR-Spider will be enhanced to account for interactions between avatars in a virtual world. The authors add to the research topic by describing existing Internet VR technologies and by proposing new ones.

De Abreu, A., Rodriguez, O., & Mateo, A. (1999, July 14-16). *Analysis and design of virtual reality applications in the Web: a case of study*. Paper presented at the IEEE International Conference on Information Visualization, 1999.

The authors, faculty at the University of Central Venezuela, investigated the problem of designing a simple house using a VRML-based 3D design tool called EVA (Editor Virtual Architecture). Other tools employed during the study were Navigator 4.5 and VRML plug-in Cosmo Player 2.1.

Overall, the paper was unclear and not well written (a poor translation may be the reason). The paper adds to the research topic by demonstrating the ability of off-the-shelf VRML software to accomplish simple viewing tasks.

Emmen, A. (1999, April 12-13). *Establishing a virtual medical worlds community*. Paper presented at the International Conference on Information Technology Applications in Biomedicine, 1999.

The paper described the newly created European "Virtual Medical Worlds Community: (VMWC). The group is focused on advancing the use of advanced technology in telemedical applications. In addition, the group will stimulate the exchange of information and expertise in areas that include VR technologies in the medical sector.

The Web-based medical community described in the paper provides access to a variety of on-line journals and aims to accelerate European technical developments in medical VR. The paper adds to the research topic by demonstrating the growing awareness of the potential of VR technologies in the field of medicine.

England, E., & Finney, A. (1999). *Managing Multimedia: Project Management for Interactive Media* (2nd ed.). Harlow, England: Addison-Wesley.

Elaine England is a multimedia consultant with extensive project management and production experience. Andy Finney her co-author is Managing Director of the Independent Multimedia Company. Their book provides detailed information about multimedia project management.

All aspects of the project development process were covered. The book adds to the research topic by illustrating the basic concepts required to successfully create the final project deliverable.

Junlan, Z., Kiat, Y., & Sung, L. (1999, February). *Architecture for a Web-based distributed virtual reality system*. Paper presented at the IEEE Internet Workshop, 1999.

The authors of the paper are researchers at the School of Applied Science, Nanyang Technological Institute, Singapore. In the paper, they describe the architecture for a Web-based distributed virtual reality system (DVRS). The system is based on a high-level architecture called "RunTime Infrastructure" that was developed for distributed interactive simulations. Images were displayed using a standard Web browser and VRML plug-in. However, the system did not support real-time video or audio.

The research found that in order to ensure the orderly delivery of packets to all users of the system a registry server was needed. This special server's sole purpose was to manage and maintain the state of the virtual environment. The authors plan to extend the research in the future with a project to incorporate multimedia in the virtual environment. The paper adds to the research topic by illustrating different techniques to manage a distributed virtual reality system.

Ko, D., Sumi, Y., Choi, Y., & Mase, K. (1999, October 12-15). *Personalized virtual exhibition tour (PVET): An experiment for Internet collaboration*. Paper presented at the IEEE International Conference on Systems, Man, and Cybernetics, 1999.

The authors are researchers at ETRI Multimedia Technology in Taijon, South Korea. The paper described the PVET (Personalized Virtual Exhibition Tour) application developed by the authors to serve as a test bed to extend personal collaboration over the Internet. PVET is a Java applet that executes virtual exhibitions.

To support collaboration between users, PVET provided agents that contained utterances. Users were able to recognize the interests of others and add to their own thoughts. The authors plan to add multi-user supports to enhance synchronous collaboration. The paper adds to the research topic by illustrating different techniques to manage a distributed virtual reality system.

Lawton, M. (1999, March-April). Advancing 3D through VRML on the Web. *IEEE Computer Graphics and Applications*, 19(2), 4-5.

Mark Lawton, the author, is Creative Director at Construct Internet Design. In the paper, Lawton described a number of VRML-based projects recently completed for clients that included Platinum technologies and CNN Interactive. The application developed for Platinum was a 3D network visualization that allowed nontechnical users easily navigate through and diagnose problems with a network. The CCN project used a large 3D polygonal object mapped with a high-resolution image of a hurricane.

One roadblock encountered by the author during the course of each of these projects was the lack of one standard VRML browser. Key to the success of future VRML applications is this standard. The author adds to the research topic with real life examples (along with the technical hurdles) of VRML applications on the Internet.

Li, T., Lien, J., Chiu, S., & Yu, T. (1999, May 26-29). *Automatically generating virtual guided tours*. Paper presented at the IEEE Conference on Computer Animation, 1999.

The authors, faculty of the Computer Science Department of the National Chengchi University, Taiwan, investigated the problem of navigating 3D landscapes with 2D user input devices (e.g. a mouse). The paper proposed an alternative navigation metaphor in which users specify locations of interest on a 2D-layout map and the system automatically generates an animated guided tour in 3D.

The system was implemented using Java and a common VRML browser interface. Also employed were auto-navigation techniques in which several efficient path-planning algorithms were used. The incorporation of Cinematographical idioms is planned for future research. The paper adds to the research topic by illustrating an effective technique to improve the usability of browser-based virtual reality applications.

Matsuba, S., & Roehl, B. (1999, March-April). "Bottom, thou art translated": The making of VRML Dream. *IEEE Computer Graphics and Applications*, 19(2), 45-51.

The authors are the founding partners of the VRML Dream Company. In the paper, they described the development of the VRML Dream project (a live performance of Shakespeare's *A Midsummer Night's Dream*). VRML Dream was the first live, streaming, VRML entertainment project with a running time of greater than two minutes. The project proved that streaming both motion and voice data over standard Internet connections was possible.

In addition, the paper described the server and client technologies required to produce the real-time 3D animation over the Internet. Future project plans involve improvements to

audio quality and enhanced interfaces for controlling avatars with motion capture equipment. The paper adds to the research project by demonstrating the viability of broadcasting 3D entertainment over the Internet.

Moore, C., McClurg, D., Soreide, N., Hermann, A., Lascara, C., & Wheless, G. (1999, September 13-16). *Exploring 3-dimensional oceanographic data sets on the Web using virtual reality*. Paper presented at the IEEE Conference - Riding the Crest into the 21st Century - Oceans '99 MTS.

The authors are faculty of the University of Washington in Seattle, Washington and Old Dominion University in Norfolk, Virginia. In the paper, they presented the results of efforts to make environmental data (i.e. oceanographic) available as interactive 3D worlds via the Internet. Included were 3D visualizations of El Niño and La Niña as monitored in the tropical Pacific Ocean.

In addition, output animations from hydrothermal plumes from sea floor volcanic eruptions were included in the project. In the future, the authors planned to develop toolkits to allow scientists to easily create VRML objects and worlds. The paper adds to the research topic by demonstrating the effectiveness of VR applications when applied to Oceanographic research.

Muller, A., Leissler, M., Hemmje, M., & Neuhold, E. (1999, June 7-11). *Towards the virtual Internet gallery*. Paper presented at the IEEE International Conference on Multimedia Computing and Systems, 1999.

The authors, researchers at TU Darmstadt in Germany, introduced an electronic service for artists and art galleries to exhibit their artwork on the Internet. The service called The Virtual Internet Gallery (TVIG) utilized a database to enhance search functionality and performed 3D visualizations of search results.

The paper demonstrated how technologies such as VRML and Java could be employed to enhance the quality of art exhibitions via an electronic system. Suggested topics for future research included the integration of video and audio or the addition of virtual shelves on which VRML models could be exhibited. The paper adds to the research topic by demonstrating another unique application of VR technology.

Nielsen, J. (1999). *Designing Web Usability*. Indianapolis: New Riders Publishing.

Jacob Nielsen, the author, is a leading authority on Web usability. He spends much of his time lecturing and writing on usability issues. His Website is located at www.useit.com. The book provided a comprehensive overview of the problems to be solved when designing a Web site. Also, the book is the first of two books that Nielsen will be publishing on the subject of Web usability.

In the chapter on content design, Nielsen discussed the proper use of 3D graphics in Web designs. Examples of good and bad designs were presented. Included in those deemed appropriate were instances in which the user was required to visualize physical objects that needed to be understood in solid form. In addition, abstract data sets (with exactly three attributes) were good candidates for 3D visualization. Nielsen adds to the research topic by describing the design challenges that VR applications present to Web usability.

Otmane, S., Mallem, M., Kheddar, A., & Chavand, F. (2000, April 16-20). *Active virtual guides as an apparatus for augmented reality based telemanipulation system on the Internet*. Paper presented at the IEEE 33rd Annual Simulation Symposium, 2000.

The authors, instructors at the University of Evry Val-d'Essonne in Evry, France, proposed the construction of a teleoperation system they named ARITI (Augmented Reality Interface for Telerobotic application via the Internet). ARITI was different from existing teleoperation architectures because of its use of active virtual guides to assist human operators (HO) with the completion of simple tasks with enhanced speed, precision, and safety. Techniques employed by the system included VR and augmented reality (AR) together with Internet-based programming.

The use of AR techniques allowed operators to superimpose virtual and real models on the same video feedback. Test results from the study showed that the use of a virtual guide together with other interface features were of great help to operators. Using virtual guides, operators were able to achieve better accuracy, performance, and safety. Future work proposed by the authors was the extension of the proposed system to mobile robotic teleoperations. The paper adds to the research topic by providing an example of how robots can be effectively manipulated using an Internet-based VR application.

**Powell, T. (1999). *The Reality of VR on the Internet*. PINT Publishing.
<http://www.pint.com/Workshop/mech1-8.htm>. Accessed October 8, 2000.**

The author, Thomas Powell, is the founder of Powell Internet Consulting an Internet research and development company in San Diego. His article provides a concise overview of the current state of virtual reality applications on the Internet.

Topics covered in the article included VRML and proprietary VR formats. The article contributed to the research by illustrating areas in which VR applications are being applied.

Regan, T. (1998, February 16-20). *Taking living worlds into people's living rooms*. Paper presented at the Third Symposium on Virtual Reality Modeling Language, Monterey, California.

The author, Dr. Tim Regan, is a researcher at BT Labs. The paper presented the results of two experiments conducted at BT Labs into Inhabited TV. The experiments used Shared VRML Worlds delivered to user's PCs via the Internet.

The study concluded that Shared VRML Worlds provided an excellent medium for experimentation on Inhabited TV. Reasons for this included the availability of a variety of authoring tools and the VRML capabilities of the available Internet browsers. The paper adds to the research topic by demonstrating the unique application of VRML technology to Inhabited TV programming.

Rosenblum, L. (2000, January-February). Virtual and augmented reality 2020. *IEEE Computer Graphics and Applications*, 20(1), 38-39.

The author is a researcher at the Naval Research Laboratory, USA. The paper looks ahead to the year 2020 to predict the progress that will be made in the field of virtual reality in the next two decades. Examples include very portable graphics computing that will provide VR and AR anywhere and anytime.

In addition, generation-after-next intelligent agent architectures will provide automated user-specific search tools. The paper adds to the research topic by suggesting one possible course that VR applications will take in the future.

Russ, K., & Wetherelt, A. (1999, March-April). Large-scale mine visualization using VRML. *IEEE Computer Graphics and Applications*, 19(2), 39-44.

The authors, researchers at the University of Exeter in the United Kingdom, demonstrated the use of VRML technology to visualize existing 2D and 3D mine plans and sections via the Internet. 3D VRML models were constructed using existing electronic digital data, paper plans, and miscellaneous reports.

Advantages gained from the use of VRML included increased rendering speed, ease of creating geometry, and Internet capability. Future enhancements include increased speed of image generation and the addition of surface buildings and general mine furniture to the model. The paper adds to the research topic by illustrating the process involved in converting existing digital and non-digital data into a working VRML model.

Safaric, R., Jezernik, K., Calkin, D., & Parkin, R. (1999, July 12-16). *Telerobot control via Internet*. Paper presented at the IEEE International Symposium on Industrial Electronics, 1999.

The authors are faculty of the Electrical Engineering and Computer Science School of Maribor University in Slovenia. Their paper described the design issues encountered

when remote access to a laboratory robotic system is provided to users via the Internet. As part of the project, simulation tools for robotic hardware were developed using VRML 97 and Java.

The result was a desktop virtual reality environment that allowed the visualization and manipulation of robotic hardware within an associated workspace. In addition, the distributed control methodology developed as part of the project eliminated unpredictable network loading problems. The paper contributes to the research topic by demonstrating one method of distributed remote control of automation systems over the Internet.

Santillo, L., Murino, T., & Paduano, G. (1999, October 18-21). *Remote controlled virtual reality construction*. Paper presented at the IEEE International Conference on Emerging Technologies and Factory Automation, 1999.

The authors, faculty at Naples University in Naples, Italy, introduced a new virtual reality method that permitted remote users to obtain a visual representation of a product request via the Internet. The method was essentially a "virtual catalogue" designed for selling compound products (e.g. furniture).

The method allowed users to interact with virtual scenery. Available tasks included the movement of an object, addition of an object, removal of an object, and change of the observation point. The advantage of the proposed model was the improved communication it provided between a company and its customers. The paper adds to the research topic by demonstrating the ability of VR applications to positively affect e-commerce transactions.

Sato, F., Minamihata, K., Fukuoka, H., & Mizono, T. (1999, September 21-24). *A reliable multicast framework for distributed virtual reality environment*. Paper presented at the IEEE International Workshops on Parallel Processing, 1999.

The authors, faculty of the school of information at Shizuoka University in Hamamatsu, Japan, proposed a new reliable multicast protocol to support many to many virtual reality environments. The protocol also provided message ordering and reliability. Unique to the protocol was its fast retransmission management and efficient retransmission buffer management based upon a local Mutual Aide Region (MAR).

Source sites using the protocol are not responsible for the receipts of all sites. This is because retransmission management is distributed into regions. Evaluation of the protocol demonstrated efficient message arrival times, and retransmission buffer sizes. Proposed future research included improvement of the restriction of message ordering and the widespread implementation of the protocol. The authors add to the research topic by demonstrating a workable solution to one of the design challenges of deploying VR technology on the Internet.

Schulz, M., Reuding, T., & Ertl, T. (1998, November-December). Analyzing engineering simulations in a virtual environment. *IEEE Computer Graphics and Applications*, 18(6), 46-52.

The authors, faculty at the University of Erlangen in Germany, presented the results of their ongoing research in the development of a virtual environment for car-body engineering applications. The technology proved to be an effective tool to communicate prototype designs between engineers over the Internet. The main advantage of the virtual environment was the intuitive navigation and interaction with the different finite element measurements employed in the car-body development process.

In addition, the ability to generate VRML files allowed the use of low-cost workstation and the Internet. Another key feature of the system was the ability to load simulation files into the virtual environment directly without any preprocessing. In the future, the authors plan to extend the project to include texture mapping and the use of iconic techniques. The paper adds to the research topic by demonstrating the effectiveness of VR techniques in enhancing engineering collaboration on the Internet.

Shi, J., Smith, T., Granieri, J., & Badler, N. (1999, March 13-17). *Smart avatars in JackMOO*. Paper presented at the IEEE Conference on Virtual Reality, 1999.

The authors are researchers at the Center for Human Modeling and Simulation, Pennsylvania University, Philadelphia, Pennsylvania. The paper describes the authors' prototype system called JackMOO. The system combines Jack, a virtual human, and LambdaMOO, a multi-user, network-accessible, interactive server. The combined JackMOO provided avatars with an increased range of human actions.

In addition, the avatars were able to express their actions in the form of imperative sentences. Future efforts of the project team will include the additional requirements to support multiple human participants. The paper adds to the research topic by showing the benefits of smart avatars when utilized in a distributed virtual training environment.

Sorid, D. (2000, July). The virtual surgeon. *IEEE Spectrum*, 37.

The author is contributing editor of IEEE Spectrum magazine. The article details the growing use of VR trainers in the medical profession. These computer-based simulators are used to hone the operating skills of surgeons before an operation. In addition to pinpointing areas of weakness, VR trainers prepare doctors psychologically for surgical tasks.

Studies have shown that the technology is at least as good as standard training methods. In the future, advances in medical graphics may soon allow ordinary medical scans of a

patient's anatomy to be enhanced into 3D virtual views. This paper adds to the research topic by summarizing current surgical VR applications.

Tannenbaum, R. (1998). *Theoretical Foundations of Multimedia*. New York: Computer Science Press.

The author, Robert Tannenbaum, is an IT administrator at the University of Kentucky. His book provides a comprehensive look into all areas of multimedia technology.

The book investigates the technical, creative, and social aspects of multimedia. In addition, the book adds to the research topic by providing a resource for basic multimedia concepts.

Terashima, N., Tiffin, J., & Rajasingham, L. (1999, June 7-11). *Experiment of virtual space distance education system using the objects of cultural heritage*. Paper presented at the IEEE International Conference on Multimedia Computing and Systems, 1999.

The authors, faculty of Waseda University in Tokyo, Japan and Victoria University of Wellington, Australia, proposed a virtual space distance education program called HyperClass. The HyperClass environment allowed teachers and students to use avatars to conduct classes and do cooperative work in a virtual classroom. In addition, the prototype of the HyperClass system developed during the project utilized 3D objects of Japanese heritage.

During the experimental phase of the project, students handled the Japanese artifacts using VR hand gestures. These tasks were facilitated by stereoscopic views of the objects from various perspectives. The paper adds to the research topic by demonstrating how avatars can be employed to increase the effectiveness of virtual distance education applications over the Internet.

Todesco, G., & Araujo, R. (2000, April 10-13). *MPEG-4 support to multiuser virtual environments*. Paper presented at the IEEE 20th International Conference on Distributed Computing Systems, 2000.

The authors, faculty of the Computer Science Department of the Sao Carlos Federal University in Sao Carlos, Brazil, addressed the current technical limitations of distributed VR systems in integrating multimedia content. In addition, the paper proposed a tool called SVRT-MM (Shared Virtual Reality Tool Integrated with Multimedia), which extends MPEG-4 to support multiuser applications.

The paper was intended to contribute to the development of a MPEG-4 standard that fully supports multiuser 3D environments. Future work will include the evaluation of the

SVRT-MM tool in regards to end-to-end latency. The paper adds to the research topic by addressing the need for enhanced standards to increase the effectiveness and usability of VR applications.

Vermeulen, H., Niekerk, T., Huang, J., & Hattingh, D. (1999, September-October). VRML to monitor and control an industrial robot via the Internet. *Africon, 1999 IEEE, 1, 561-564.*

The authors, researchers at the Manufacturing Technology Research Center in Port Elizabeth, South Africa, described the methodology they followed to model an industrial robot manipulator in VRML. During the project, a VRML model of a robot manipulator was constructed to replicate a commercially available ABB material-handling robot. The VRML model was able to control and monitor the manipulator via the Internet. The advantage gained by such a system was the ability of production operators to remotely visualize the robotic system within the factory environment.

The study reported in the paper demonstrated that VRML and the Internet were powerful tools for extending robot control to include remote 3D monitoring and control. The authors proposed that other researchers extend the project to include intelligent control of complete robotic cells. The paper adds to the research topic by demonstrating an effective and usable manufacturing system employing VR technology

Reference List

- Bayne, K. (1997). *Internet Marketing Plan*. New York: John Wiley & Sons, Inc.
- Bourdakis, V. (1997). *The future of VRML on large urban models*. Paper presented at the UK VRSIG 97, Somerset, UK.
- Branaghan, R. (1999). Testing, one -- two -- three: Fundamentals of usability testing. *Fitch*. http://www.branaghan.com/fun_utesting.htm. Updated October 5, 1999. Accessed September 30, 2000.
- Copernic (2000). Copernic 2000. <http://www.copernic.com>. Accessed October 8, 2000.
- England, E., & Finney, A. (1999). *Managing Multimedia: Project Management for Interactive Media* (2nd ed.). Harlow, England: Addison-Wesley.
- Jordan, P. (1998). *An Introduction to Usability*. Bristol, Pennsylvania: Taylor & Francis.
- Li, T., Lien, J., Chiu, S., & Yu, T. (1999, May 26-29). *Automatically generating virtual guided tours*. Paper presented at the IEEE Conference on Computer Animation, 1999.
- Matsuba, S., & Roehl, B. (1999, March-April). "Bottom, thou art translated": The making of VRML Dream. *IEEE Computer Graphics and Applications*, 19(2), 45-51.
- McKeown, K., Feiner, S., Mukesh, D., & Chang, S. (1998). Generating multimedia briefings: coordinating language and illustration. *Artificial Intelligence*, 103, 95-116.
- Powell, T. (1999). The Reality of VR on the Internet. *PINT Publishing*. <http://www.pint.com/Workshop/mech1-8.htm>. Accessed October 8, 2000.
- Regan, T. (1998, February 16-20). *Taking living worlds into people's living rooms*. Paper presented at the Third Symposium on Virtual Reality Modeling Language, Monterey, California.
- Rubin, J. (1994). *Handbook of usability testing*. New York: John Wiley & Sons, Inc.
- Sellers, D. (2000). QTVR Used in Panoramic Image Offerings. *MacCentral Online*. <http://www.maccentral.com/news/0002/29.qtvr.shtml>. Updated February 29, 2000. Accessed October 19, 2000.
- Silverman, D. (1998, May 27, 1998). Balance PC needs with cost, life span. *Houston Chronicle*.

Tannenbaum, R. (1998). *Theoretical Foundations of Multimedia*. New York: Computer Science Press.

Vernick, M., Venkatramani, C., & Chiueh, T. (1996). Adventures in building the Stony Brook video server. *Proceedings of the Fourth ACM International Multimedia Conference on Proceedings ACM Multimedia 96*, ACM, Boston, pp. 287.