Web-Based Simulation and the Virtual Reality Modeling Language

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Several prototype VRML applications have been developed for STRICOM to demonstrate the benefits of three-dimensional modeling and simulation environments in support of ADL. This paper will outline the VRML applications developed thus far, including a simulator that uses VRML and the High Level Architecture (HLA) to allow multipledesktop PCs to engage in a virtual battle over the Internet. In addition, the paper will examine other emerging Internet standards from the Web3D Consortium and ADL's Sharable Courseware Object Reference Model (SCORM) to determine how they will impact the use of three dimensional simulations in future web-based training environments.

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INTRODUCTION

The U.S. Army Simulation, Training and Instrumentation Command (STRICOM) is currently exploring web-based simulation technologies to support Advanced Distributed Learning (ADL) environments. One emerging industry standard is the Virtual Reality Modeling Language (VRML) which allows stunning three-dimensional images to be delivered over the World Wide Web (WWW). Leveraging the constantly increasing power of the personal computer (PC) and Internet communication technologies, these three dimensional simulation environments can be delivered *anytime-anywhere*.

Several prototype VRML applications have been developed for STRICOM to demonstrate the benefits of three-dimensional modeling and simulation environments in support of ADL. This paper will outline the VRML applications developed thus far, including a simulator that uses VRML and the High Level Architecture (HLA) to allow multiple desktop PCs to engage in a virtual battle over the Internet. In addition, the paper will examine other emerging Internet standards from the Web3D Consortium and ADL Initiative's Sharable Courseware Object Reference Model (SCORM) to determine how they will impact the use of three dimensional simulations in future web-based training environments.

ADL

Advanced Distributed Learning (ADL), as defined by the Department of Defense (DoD) Strategic Plan (April 30, 1999), leverages the full power of computer, information, and communication technologies through the use of common standards to provide learning that can be tailored to individual needs and delivered *anytime-anywhere*. ADL technologies offer unique advantages over traditional instructional methodology such as reduced reliance on full-time instructional staff and the ability to be distributed to remote sites. There is no doubt that society in general is moving quickly towards increasing the use of technology as an aid to human performance. In particular, disseminating information across the Internet has become more versatile, reliable, inexpensive, and user-friendly than ever before.

VRML

VRML is an open standard for distributing 3D multimedia and shared virtual worlds on the Internet and was recognized as an international standard (ISO/IEC-14772-1:1997) by the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) in December, 1997. VRML has long been the de facto standard for sharing and publishing data between CAD, animation, and 3D modeling programs, many of which can export their output to VRML format. The capability of having shared virtual worlds over the World Wide Web (WWW) was a primary motivator behind the development of VRML. Unlike previous 3D applications, using the Internet to share 3D objects and scenes was built into the VRML standard from the very beginning.

VRML provides compelling support for attaching or 'hyper-linking' augmented content to any arbitrary three-dimensional object or feature in the displayed view. While features such as platform independence, three-dimensional graphics, and Internet-friendly user interface are not the unique domain of VRML, it is important to note that such capabilities are realized in VRML in an open, standards-based

modeling language framework versus a Java or C++ programming language implementation.

This paper focuses on the use of web-based modeling and simulation (M&S) within the ADL domain including key graphics and audio technologies that describe three-dimensional (3D) objects across the WWW. Such technologies are often referred to as Web3D technologies. Web3D technologies, and VRML in particular, have been used successfully in the commercial world primarily for web page design. STRICOM is extending the uses of Web3D as an ideal low-cost medium for M&S to support ADL environments.

VRML APPLICATIONS

Several prototype VRML applications have been developed to demonstrate the benefits of web-based M&S. These applications support visualization of objects, procedures, and military tactics as well as distributed interactive simulation.

Object Visualization

Soldiers new to the Army and those on reserve often have difficulty understanding the intricate details of military equipment such as weapons, vehicles, tools, and armament. Using three-dimensional graphics to visualize equipment has proven to be a very effective learning technique. Moreover, utilizing VRML to depict the graphics allows for distance learning over the Internet.

The tank visualization demonstration illustrates the basic characteristics of a tank. Three-dimensional VRML models of the M1A1 are provided. The user can select several different viewpoints to learn more about tanks. For example, the user can select a viewpoint that transports him inside the tank to see the various crewmember positions (see Figure 1). The user can also select various parts of the tank in order to see different animations, showing the full range of motion of the main gun and turret, opening of the crew doors, or the commander's popped hatch.

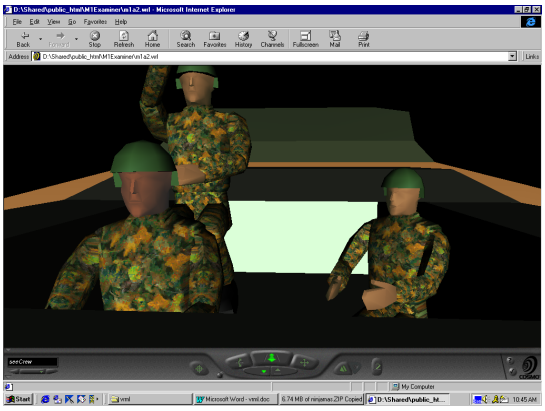

Figure 1. View of Crew Inside of Tank

Concept/Procedures Visualization

Using VRML animations, procedures can be demonstrated in the ADL environment. One example of procedure visualization is the Visual Signaling demonstration. The United States Army has designated several different types of visual signaling techniques used for special emergencies, warnings, combat formations, battle drills, fire control, and infantry fire team communication. VRML has been used in this example to replace a handbook given to soldiers during battlefield training sessions. Visualizing the gestures in three-dimensions is much more intuitive and easier to remember than reading a description in a document.

The user of this application chooses a gesture by simply clicking on the desired gesture on the selection wheel. When the gesture is selected, the computer-generated avatar moves his arms according to doctrine to demonstrate the selected signal. In addition, information describing the gesture in more detail is presented to the user in a text box next to the avatar. A total of 26 different gestures are available on the selection wheel. The user may rotate the selection wheel by clicking on "Rotate." Clicking on "Stop" stops the wheel. In addition, the user can select pre-defined viewpoints such as top, side, or front views, or can use the navigation bar to select any imaginable vantage point (see Figure 2).

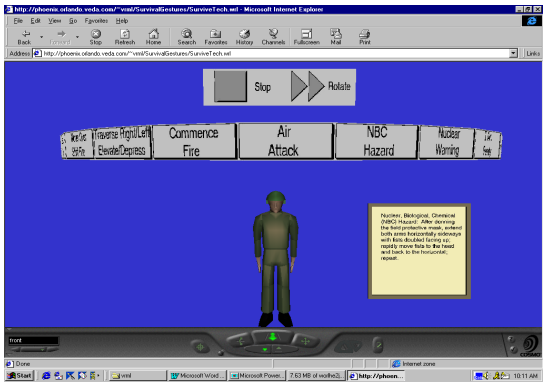

Figure 2. Visual Signaling Demonstration

After the student has learned the gestures at his own pace, he takes an assessment quiz. The assessment portion displays a soldier making a gesture, then the student has to click on the correct answer. According to Army doctrine, the student is given a total of 10 gestures, and must get every one correct in order to pass the evaluation.

Tactics Visualization

Using VRML animations, soldiers can visualize the proper tactics to be used in a military exercise, prior to its commencement. This demonstration depicts two infantry squads consisting of four fire teams assaulting a building. Each fire team consists of four individuals with two fire teams forming a squad. Fire teams maneuver throughout the battlefield in a very organized and precise regimen.

The VRML demonstration was constructed following detailed pictorials contained in the exercise plan. First, a hole is blown in the building to start the action by clicking on a spot on one of the buildings. The building will then open up into two distinct levels, allowing simultaneous viewing of activity on each floor. The soldier can watch as the VRML simulation shows the fire teams moving from room to room, properly clearing the building (see Figure 3). This visual demonstration takes the place of a nearly 50 page document and can easily be delivered over the WWW.

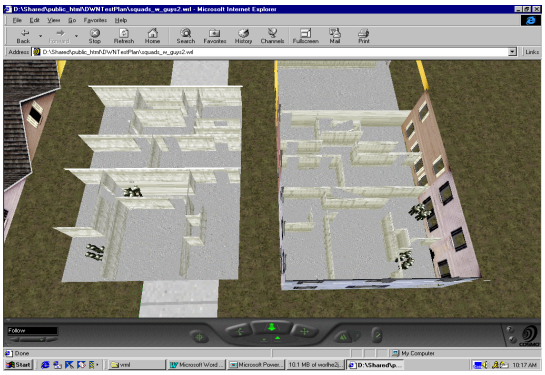

Figure 3. Exercise Plan Viewer

Collaborative Simulation

While VRML is not ideally suited for dynamic rendering of complex "out-the-window" views at high frame update rates, three-dimensional navigation through fairly large and complex VRML virtual environments is achievable with adequate performance on today's personal computers. The RealGuy Web3D application demonstrates that VRML can be used as a visual display system in a low-cost simulator. RealGuy Web3D can be used to passively view the simulation as a stealth viewing tool, or the user can actively participate as one of the individual combatant entities in the simulation. A number of RealGuy Web3D applications can operate simultaneously, interacting in a common virtual environment. The important thing to realize is that web-based simulation can now participate in long-haul simulation exercises from any PC in the world, without the need to pre-install the RealGuy Web3D software. The user simply logs into the server machine located on the same network as the simulation exercise, and becomes an active participant in the exercise using commercial standards such as Java, VRML, and TCP/IP client/server technology (see Figure 4).

Various postures can be manipulated using the graphical user interface by selecting the standing, kneeling, crouching, or prone position. The user can also place the weapon in the stowed or deployed position. Firing interaction between the entities is possible by placing the cursor on the other entities and pressing the mouse button. This causes a shot to be fired. If a soldier has been killed, his navigation bar will

disappear, and the graphical user interface can be used to restore his life.

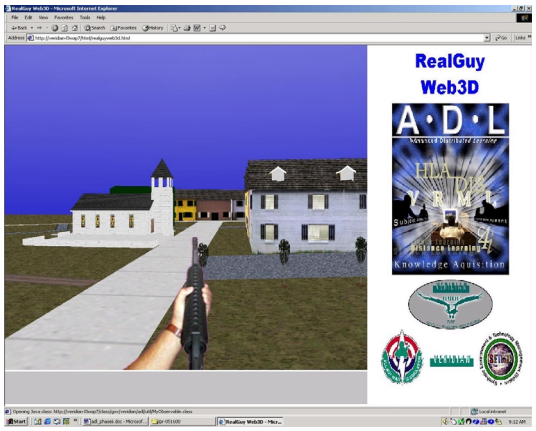

Figure 4. RealGuy Web3D

RealGuy Web3D allows one or more users to interact in a shared VRML world. One of the training databases supported by this application is the McKenna military training site, located at Ft. Benning, Georgia. The basic goal of the application is to provide a means for soldiers to interact with each other, and also with computer generated forces, which are controlled through the Modular Semi-automated Forces (ModSAF). ModSAF can generate humans, tanks, planes, and helicopters, which are all rendered in the VRML world. Once the entities are created, ModSAF can be used to control their movement and allow the entities to engage the RealGuy Web3D entity in a virtual battle. The RealGuy Web3D application will allow a user to be immersed in the same virtual environment as the ModSAF-controlled humans, tanks, planes, and helicopters. Using client/server technology, this participation can take place from anywhere over the Internet, and one or more RealGuy Web3D users can participate in the simulation exercise simultaneously (see Figure 5).

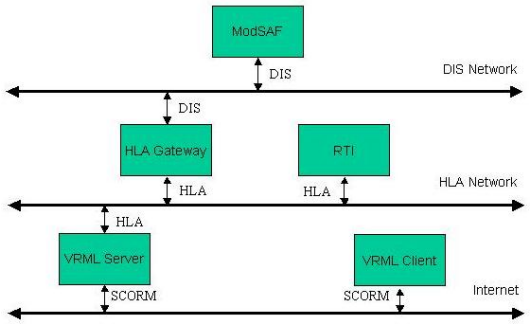

Figure 5. RealGuy Web3D Block Diagram

The application is built using Java and VRML programming languages, and makes extensive use of the External Authoring Interface (EAI) and client/server technology. HTML and JavaScript also form a portion of the technology. The RealGuy Web3D application really includes two components: a VRML Server and a VRML Client. This application showcases a true collaborative environment for distributed learning and training. The technology used to share information between simulators is the High Level Architecture (HLA). The HLA is a general-purpose architecture for simulation reuse and interoperability, developed by the U.S. Department of Defense (DoD) and is now in the process of becoming an open standard through the Institute of Electrical and Electronic Engineers (IEEE).

The HLA Gateway performs the task of a protocol translator between DIS and HLA, for integration with ModSAF and other DIS-compliant simulators. In this demonstration, ModSAF "speaks" DIS, and the RealGuy Web3D application "speaks" HLA. The protocol translator allows them to talk to one another. In this demonstration, the HLA Gateway and the VRML Server portion of RealGuy Web3D both communicate information such as position, orientation, velocity, posture, firing information, and type using HLA's Run-time Infrastructure (RTI) as a facilitator.

The VRML Server performs the function of listening for ModSAF entity information received from the RTI. It also listens for VRML Client information received from the client/server interface. The server must perform several coordinate conversions on incoming data, to put into a formats understood by the HLA and VRML applications, then relay the information out to the RTI and all of the clients that are participating in the exercise. The VRML Server runs on the same local area network as the ModSAF, HLA Gateway, and RTI applications, and can even run on the same machine.

The VRML Client is the application that is seen by the end user. This application loads in the

shared VRML database, then uses the EAI to update models of humans, tanks, planes, and helicopters within the database. The EAI is also used to determine the user's position, orientation, velocity, type, and posture to allow other simulators to see the user's entity in the proper perspective. The VRML Client communicates to the VRML Server using client/server protocols over the Internet using TCP/IP port communication.

It is important to note that RealGuy Web3D application can run without the ModSAF, HLA Gateway, and RTI applications. One or more VRML clients can communicate with the VRML Server and operate in a distributed simulation environment without the need to operate with the ModSAF computer generated forces tool. However, the interest in the Army is to develop applications that are compliant with standard simulation protocols for the purpose of simulation interoperability within an advanced distributed learning framework.

WEB3D CONSORTIUM

The VRML standard was developed by the Web3D Consortium, which provides a forum for the creation of open standards for Web3D specifications. STRICOM is now a charter member of the Web3D Consortium, which also sponsors education programs to accelerate the acceptance and demand for these standards-based products. The Web3D Consortium has joined the World Wide Web Consortium (W3C) to ensure that the next generation of multimedia standards for the web include seamlessly integrated 3D graphics.

Current technical activities of the Web3D Consortium include the development of the Extensible 3D (X3D) specification, which is extending VRML97, using the Extensible Markup Language (XML). The X3D specification will be interoperable with other emerging web standards and compatible with the existing VRML standard. X3D will include advanced rendering capabilities including realistic character animation, and advanced rendering effects including multi-textures, streamable datatypes and non-polygonal surface descriptions. X3D will be incorporated into the next-generation open, non-proprietary VRML ISO standard targeted for 2002.

SCORM

DoD has recognized the benefits of technology-based instruction and has undertaken the ADL Initiative to increase its use. To improve the efficiency of investments in technology-based instruction, a reference model has been developed to support the creation of web-available, reusable courseware objects. These objects will be "reusable in the development of technology-based instruction, portable across different presentation platforms, accessible through the use of metadata standards for identifying and locating them, and durable across different versions of operating systems, browsers, and other supporting systems software."

For learning content to be reusable in multiple applications and environments regardless of the tools used to create it, the content must be separated from context-specific run time constraints. The SCORM accomplishes this by defining standard interface points between content and the Learning Management Systems (LMS) that control the delivery of the content to students. The SCORM also defines metadata formats for the content that will allow courseware developers to search and find reusable content in a repository. For VRML applications to be SCORM compliant, the applications will have to support the SCORM's runtime environment with its associated interface protocol and provide appropriate metadata for the content.

SUMMARY

Several VRML M&S applications have been described above. Through these examples, it has been shown that with increasing bandwidth for the Internet and increasing personal computer performance, VRML can be used in ADL environments supporting instructional systems design strategies such as 3D object, procedure, and tactics visualization as well as support for distributed interactive simulation.

Emerging technologies and standardization efforts will make ADL environments more engaging and more cost effective. Standards organizations such as the Web3D Consortium

will ensure that rich, multimedia content, including 3D graphics can be seamlessly delivered over the web. And as the SCORM matures and the DoD's vision of reusable content repositories comes to fruition, VRML-based courseware objects will be available as building blocks to support ADL courseware development.

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