Task 2.1 Command & Control Visualization: Year 4

Ronald D. Kriz and Lance E. Arsenault
Engineering Science and Mechanics
rkriz@vt.edu / lanceman@vt.edu
Desk: (540) 231-2062 / (540) 231-2641
FAX: (540) 231-9187 (540) 231-2056

Abstract:

Creating a detailed picture of a battlefield terrain, weather, and military resources is vital for the success of a military mission. In a virtual immersive environment, such as a CAVE, Immersive-Workbench, or Head Mounted Display (HMD), mission planners and command and control (C&C) personnel can gain a tactical advantage. Because of the inherent three-dimensional nature of immersive environments, C&C personnel can better plan the distribution of military resources on land and at sea both above and below the surface. Much of the tactical information, which is lost in a traditional map, can be accessed and used for mission planning in an immersive three-dimensional environment. With the aid of super-computers it is also possible to include discrete simulation models of tactical systems as well as physically realistic simulation models of other mission critical C&C activities such as crane-ship motion and underwater acoustic phenomena related to undersea warfare. Our experience in creating prototype C&C simulation model applications in collaboration with Navy C&C researchers has positioned us to provide technical leadership in future C&C application programming interface (API) software tool development.

Visualization of Simulation Model Results—

During our second year we focused on a mission critical C&C activity that required interpretation of acoustic data for the Navy Undersea Warfare Center (NUWC) CONRAY project. Acoustic simulation models used by NUWC are highly dependent on physically realistic models. Again virtual immersive environments can aid in creating necessary data displays for the interpretation of complex 3D acoustic structures generated from simulation models. These models require real-time acquisition of data such as bottom bounce and heterogeneous 3D water topologies, which are unique to each tactical situation.

In our third year we want to generalize the development of a software Application Programming Interface (API) for C&C visualization that can be used for a variety of tactical systems. For example a variety of other C&C activities of interest to the NUWC and the Virtual Reality (VR) Lab at the Naval Research Lab (NRL) requires that reality be integrated with simulation model results. Researchers at the NRL-VR Lab are also rethinking how software and hardware technical issues will influence their future development of software APIs that can be effectively used to build applications such as the Interoperable Virtual Reality System (IVRS). IVRS developed at NRL requires a fusion of a variety of external systems to give a common tactical picture across multiple levels of the network-centric battle-space. Our second year CONRAY project has required collaboration between NUWC, NRL and VT to develop C&C tactical simulations in immersive environments which where based on NRL's DRAGON and VT's DIVERSE APIs. Our third year requires independent development of IVRS and DIVERSE APIs based on OpenGL and with the integration of the Open-Inventor scene-graph. On January 2002 a final API, IVRS or DIVERSE, will be selected for NUWC's FNC (Future Navy Capabilities) project. IVRS will be developed at NRL and DIVERSE will be developed at Virginia Tech.

In our fourth year we will focus on further development of the OpenGL/OpenInventor API. With the chosen API the CONRAY tactical C&C simulation application will be developed in year four to facilitate data visualization and C&C on HP workstations on-board submarines for the NUWC FNC. The CONRAY application will include 3D water topologies, bathymetry, metrological structures; be it multi-variate, time series, GIS, or general volumetric data to be determined by our Navy POCs.

Description of Proposed Research:

From our experience of working with Navy C&C software application developers, our group is in a unique position to build on these existing relationships and provide technical leadership in the creation of new C&C APIs. In our third year we continued to work with NUWC & NRL on completion of the CONRAY C&C simulation model application, as outlined in the February 12, 2001 quarterly report on Task 2.1. Key NUWC and NRL researchers collectively agreed that SGI-Performer-based software APIs such as IVRS and DIVERSE have serious limitations in building future C&C applications. The consensus is to develop OpenGL-based software APIs that will allow researchers to build C&C applications across heterogeneous operating systems: IRIX, Linux, HP-UX, and Microsoft Windows. Because the specific API design and features are not yet defined we will continue to work closely with key C&C Navy personnel at NUWC and NRL as we build this API. For example Navy POCs will provide a format for future Navy data base standards.

The objective here is provide technical leadership in building a **well documented** C&C OpenGL-based API that will be extensible for future C&C development at NUWC and NRL. This API is a “glue” that will foster integration and collaboration with our Navy point-of-contact (POCs) and NAVCIITI CoPIs. As authors of this OpenGL based API, we can provide technical leadership with other C&C NAVCIITI applications such as the Digital Ship, Virtual Crane Ship simulation, etc. We will also work closely with NAVCIITI CoPI, Dr. Debby Hix, on usability and evaluation issues as we create this new API. We propose to continue the division of two Tasks: Task 2.1a) development of the CONRAY application as proposed in year three, and Task 2.1b) development of an OpenGL based API. Task 2.1b will be the **C**ollaborative-**I**ntegrated “glue” concept that was originally proposed as the **CI** in the NAV**CI**ITI acronym. Because Task 2.1b required technical experience in building APIs, Dr. Lance E. Arsenault was selected as the NAVCIITI CoPI in year three, who is responsible for development of this new task. Dr. Arsenault created the DIVERSE ToolKit (DTK) portion of DIVERSE that was used to link the device independent virtual environment components of the ONR-DURIP Navy crane-ship CAVE project. Because of Dr. Arsenault’s experience in design and implementation of complex VE systems, this C&C API will link with NAVCIITI networked systems. Ronald D. Kriz will continue to be the CoPI of Task 2.1a, which will be reduced and focus only on developing applications with the C&C API developed in Task 2.1b such as CONRAY for NUWC’s FNC. Task 2.1a will continue to fund the existing graduate student, who developed the CONRAY application from the Performer-based DIVERSE API, and associated expenses for travel and equipment. For Task 2.1b Mr. John Kelso will continue to work on Task 2.1b. Mr. Kelso was the creator of the DIVERSE graphics interface to Performer (dgiPf) and the advisor on a project where an OpenGL API prototype was built as a class project for ESM4714. Together Lance and John’s experience will provide the technical leadership for developing future **C**ollaborative-**I**ntegrated C&C tools such as DIVERSE. Our group has already built an OpenGL DIVERSE API prototype. From this experience we justify the need for two new GRAs to assist in the construction of this new API. These two tasks are outlined below.

- Task 2.1a:
  - Development of CONRAY C&C acoustic simulation model based on API in Task 2.1b

- Task 2.1b:
  - Create OpenGL API for IRIX, Linux, HP-UX, and Windows-OS
  - Investigate how to incorporate OpenGL scenegraphs such as OpenInventor
  - Integration of networked device tools (FLTK, PocketPCs, Voice Recognition, etc.)
  - Create new navigation tools in collaboration with NAVCIITI CoPI Debby Hix
  - Create GUI manager for DTK

Statement of Work:

Year 4: Task 2.1a Develop CONRAY application on OpenGL API

2.1a.8: *Evaluate and modify NUWC CONRAY model,* ***May 02***
2.1a.9: *Create interfaces (DSOs) for HMDs, IWBs, and desktop flat panel displays, across heterogeneous operating systems: IRIX, Linux, HP-UX, Windows,* ***August 02***

2.1a.10: *Incorporate interactive-collaborative tools into dgiGL CONRAY model,* ***March 03***
2.1a.13: *Final report on NUWC dgiGL CONRAY model,* ***April 03***

Year 4: Task 2.1b Develop OpenGL C&C API

2.1b.9: *Create interactive interface tools, i.e. GUIs and gesture-based interfaces,* ***May 02***
2.1b.10: *Implement loaders for high-level graphical objects or scenegraphs,* ***August 02***
2.1b.11: *Expand and refine DTK management tools,* ***October 02***
2.1b.13: *Prototype data type visualization programs using above tools,* ***May 03***
2.1b.14: *Final report,* ***April 03***

Technical Approaches:

For task 2.1a development of the CONRAY simulation model will be largely dependent on the development of the OpenGL C&C API proposed in Task 2.1b. Until the Task 2.1b SOW 2.1b.3 is completed in September 01, we will continue development of the Performer-based CONRAY simulation model, which will be useful in the interim with IRIX and Linux operating systems.

For task 2.1b development of the OpenGL C&C API, dgiGL, will be used by the CONRAY application, although it will designed to be an application-independent API. The dgiGL API will depend on the DIVERSE Toolkit (DTK) API, a separate standalone package, which will be used by dgiGL to provide access to local and networked VE interaction devices and other utility that is not directly related to graphics. Only software modules that depend on OpenGL will become part of dgiGL. This separation of tasks simplifies DIVERSE development. DTK is currently being used by dgiPf, the DIVERSE graphics interface to Performer, which is in turn used in the current implementation of CONRAY. It is intended that DTK will be of more general use than dgiGL. As much as possible all DIVERSE graphics APIs will augment the existing graphics API of the user's code, which will not force application programmer into using a particular design paradigm.

Key Personnel

Ronald D. Kriz is an associate professor in the Departments of Engineering Science and Mechanics. His research interests include modeling damage development in fiber-reinforced composites and nondestructive ultrasonic and optical methods for detection of damage and monitoring degradation of properties in composites. Dr. Kriz founded the laboratory for Scientific Visual Analysis in 1990 that is now the University Visualization and Animation Group, which was a NSF NCSA-PACI CAVE Alliance Partner. The alliance uses supercomputer resources across a national grid where CAVEs were used to interpret simulation results. His research is mostly wave propagation phenomena and he also supports other CAVE related educational and research activities across the campus as part of Virginia Tech’s new Advanced Communication and Information Technology Center.

Lance E. Arsenault is a Research Assistant Professor at Virginia Tech. He has a PhD in Physics (1996) from the University of Illinois at Urbana. His current research is concentrated on the development of a real-time CAVE and virtual prototyping system and the development of VE software APIs. He is a co-author of the DIVERSE project (http://www.diverse.vt.edu/) and the primary author of the DIVERSE ToolKit (DTK). Prior to working at Virginia Tech, before May 1999, he was employed by the National Center for Supercomputing Applications (NCSA) as a research programmer, concentrating on VR and engineering applications for Caterpillar Inc., in NCSA's industrial partners program. Before that he finished his physics PhD thesis in the field of nonlinear dynamics in the fall of 1996 at the University of Illinois at Urbana.