Task 2.1 Command & Control Visualization: Year 3

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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 augmented 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. The complexity of such systems requires usability evaluations based on formal evaluation methodology. 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.

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. We propose to continue to work closely with C&C projects at NRL and NUWC that require co-development of new C&C visualization software APIs that can be used in the future to build a variety of C&C applications such as CONRAY and IVRS. In our third year we will continue 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. But after close communication with key NUWC and NRL researchers we collectively agree that SGI-Performer-based software APIs such as DRAGON 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 an OpenGL-based C&C API.

The objective here is provide technical leadership in building a **well documented** C&C OpenGL prototype API that will be extensible for future C&C development at NUWC and NRL -- possibly fourth year funding at VT. This well documented API is a "glue" that will foster integration and collaboration with our Navy POCs and NAVCIITI CoPIs. As authors of this OpenGL API, we can provide technical leadership with other C&C NAVCIITI applications such as the Digital Ship, Virtual Crane Ship simulation, etc. Similar to the development of C&C applications at NRL we will also work closely with NAVCIITI CoPI, Dr. Debby Hix, on usability and evaluation issues as we create this new API. Because the development of this C&C API is technically based we propose to divide Task 2.1 into two Tasks: Task 2.1a) continue development of the CONRAY application as proposed, and Task 2.1b) a new task that will require new technical leadership in the development of an OpenGL 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 will require technical experience in building C&C APIs, we propose that Dr. Lance E. Arsenault be included as an new NAVCIITI CoPI responsible for development of this new task. Dr. Arsenault created the DIVERSE ToolKit (DTK) of DIVERSE that was used to link the device independent virtual environment components of the Navy crane-ship CAVE project. Because of Dr. Arsenault's experience in design and implementation of network centric VE systems, the proposed C&C API will link with NAVCIITI network 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. Task 2.1a will be reduced to funding 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 be moved into the the new Task 2.1b, reducing the budget of Task 2.1a. 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. Because our group has already built an OpenGL API prototype we can justify the requirement of an additional two GRAs to build this new API. These two tasks are outlined below.

- Task 2.1a:

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

- Task 2.1b:
  - Create OpenGL API for IRIX, Linux, HP-UX, Window
  - Investigate how to incorporate OpenGL scenegraphs
  - Integration of networked device tools (FLTK, PocketPCs, Voice Recognition, etc.)
  - Create new navigation tools in collaboration with Debby Hix
  - Expand on network extensions for the DIVERSE toolkit with data abstractions & security
  - Create GUI manager for DTK

Statement of Work:

Year 3: Task 2.1a Develop CONRAY application on OpenGL API

2.1a.4: Evaluate and modify CAVE display interfaces for NUWC acoustic model, ***July 01***
2.1a.5: Work with NAVCIITI usability group to address usability issues in future SOWs, ***June 01***
2.1a.6: Design NUWC CONRAY model on OpenGL API, ***October 01***
2.1a.7: Demonstrate NUWC CONRAY model, ***February 02***

2.1a.8: *Evaluate and modify NUWC CONRAY model,* ***March 02***
2.1a.9: *Through out development create collaborative interfaces to work with HMDs, IWBs, and flat panels, across heterogeneous operating systems,* ***April 02***
2.1a.10: *Final report on NUWC CONRAY,* ***April 02***

Year 3: Task 2.1b Develop OpenGL C&C API

2.1b.1: *Report on dgiGL API with navigation base class and recommended scenegraph,* ***July 01***
2.1b.2: *Extend DTK networked hardware devices: demo PocketPC, FLTK tools, and voice,* ***August 01***
2.1b.3: *Create dgiGL with navigation examples on SGI,* ***September 01***
2.1b.4: *Demonstrate dgiGL/DTK on HP-UX,* ***October 01***
2.1b.5: *DTK data abstractions including remote shared memory streamed data,* ***November 01***
2.1b.6: *Demonstrate dgiGL/DTK in Microsoft Windows,* ***December 01***
2.1b.7: *Add DTK network connectivity topology management,* ***January 02***
2.1b.8: *Demonstrate dgiGL with scenegraph and widget based manager for DTK,* ***February 02***
2.1b.9: *Add DTK security layer,* ***March 02***
2.1b.10 *Final report,* ***April 02***

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 is a NSF NCSA-PACI CAVE Alliance Partner. The alliance uses supercomputer resources across a national grid where CAVEs are 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 in the Engineering Science and Mechanics (ESM) Department 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 motion based 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.