Visual Computing @ Virginia Tech

3/4-Term Report: March 2007

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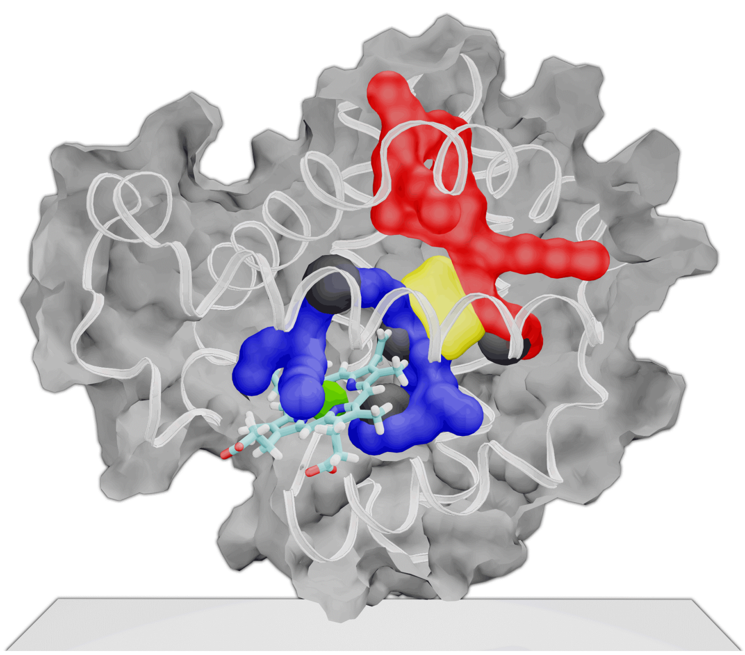


Data from System X molecular dynamics simulation as a 3D virtual environment

1. Overview

In its first eight months, the Post-doctoral position created in Virginia Tech Information Technology for 2006-2007 has enabled significant progress and opportunities for the Virginia Tech Community. The position has served several important functions in advancing the University's Visual Computing capabilities and paving the way for further progress. Through personnel reorganization and improvements to hardware and software infrastructure, the activity and tenor of activities surrounding visualization have become quite positive.

The goals of adoption and access for the VT community have been pursued through a number of avenues such as spring and summer FDI courses ("Deep Media for Research and Education") as well as a credit GEDI course ("Introduction to Computational Science"). Specific, high-impact projects were also targeted to demonstrate the technology and value of Visual Computing in the research enterprise. Through a series of project-consultations and development, the Visual Computing team has delivered solutions for cutting-edge computational scientists in domains as varied as Molecular Dynamics to Space Energetics to Spatial Statistics Analysis. The results are shown throughout this report.

We have continued to further VT's leadership and recognition in enabling visualization tools and technologies. VT Visual Computing has actively engaged in the specification of international standards for networked interactive 3D media and user interfaces (Web3D / ISO) as well as 3D medical imaging (DICOM). During this time we have also notably contributed to numerous well-regarded international conferences as: program co-chair, workshops chair, workshop organizer, paper presenter, panelist, and exhibitioners.

Our initial successes provide guidance as to how we may meet the multiple requirements of world-class research, education, and outreach. Transferring technology insights from CS and HCI research into applied solutions for scientists, students, and citizens. We hope to forge stronger partnerships and networks of support within the University, the Commonwealth, and national agencies. With the common goals of enabling knowledge and discovery, we hope to advance the VT Visual Computing program and grow the vibrant and innovative environments of next-generation communication. The future of visualization at Virginia Tech depends sustained commitment from the community and the administration for personnel, equipment, and software resources.

2. Capabilities

One of the main goals of year one was to improve the capabilities of VT's Visual Computing infrastructure. This included restructuring personnel and expanding hardware and software to reliably serve more members of the VT community.

a. *Personnel*

i. Engineering Education & NSF Center for eDesign

In order to build more momentum behind the use of 3D visualization in research and education, we initiated and completed the relocation of Dr. Janis Terpenny and her NSF Center for eDesign to the CAVE lab in Torgersen hall. Dr. Terpenny's research in design process and prototyping strongly complements the capabilities of the Visual Computing Group. Her collaborators, industry contacts and students continue to drive innovative applications of visual methods in engineering.

ii. VR systems Engineer

A VR Systems Engineer is crucial for the maintenance and development of VT's cutting-edge visualization and immersive systems. IT and the Research Division have secured one year of continued support for Patrick Shinpaugh, an experienced developer and administrator. We recommend this position be made permanent to facilitate operations and maintain access to software, hardware, and files for HPC, stereo wall and CAVE systems across campus and the CRC.

iii. Post-Doctoral Associate

The pilot position as facilitator and enabler of visualization applications for Research Computing has proven to meet an important need of the community by connecting researchers and their data through best-of-breed technology and tools. In addition, consulting, development, and grant proposals have resulted in a number of successful and high-profile projects and publications (described in the following sections). The flexibility to meet new opportunities and liaison with multiple stakeholders is important for this role.

Significant progress has been made in supporting faculty research and education through this position. In addition, significant progress has been made in advancing VT's international leadership in cutting-edge technologies. However, the nature of a post-doctoral position has some limitations in fully meeting the needs of all the Visual Computing activities on campus. For example, faculty and students from many colleges use the CAVE and Stereo wall facilities for research, classes and outreach and to great benefit. However, there is no funding stream in place to support educational and outreach activities involving these resources. The CAVE is an essential research and pedagogical tool as well as a flagship publicity venue.

We recommend that a Directorship position be created to take over management and administrative duties related to Visual Computing facilities around campus, including the CAVE. This position should have a base funding stream for salaries, overhead, and maintenance in serving the VT community for 3-5 years. More staff may be added in coming years, but in the short term, a set of students internships and GRAs should also be created that would assist in developing web-based interactive 3D environments for class and public communication. Graduate and Undergraduate students can scale the impact of visualization technologies across domains.

In all aspects of visual computing and communication, 'Content is King'. With more groups on campus producing interactive 3D data and environments, providing multiple avenues to build authors' skill sets will be valuable. Student wage staff could assist in running scheduled and special-case tours of the facilities. With additional consensus toward a positive broad-based plan and with financial support from the University, we believe VT can make quantum progress in visualization, in line with other top-tier schools and national labs.

b. Hardware Facilities

i. VT CAVE

Virginia Tech's flagship immersive venue, the CAVE, has provided an environment for world-class innovation since its founding in 1997. The successful philosophy of open access should continue. However, the hardware technology at the VT CAVE is aging and in need of replacement or upgrade.

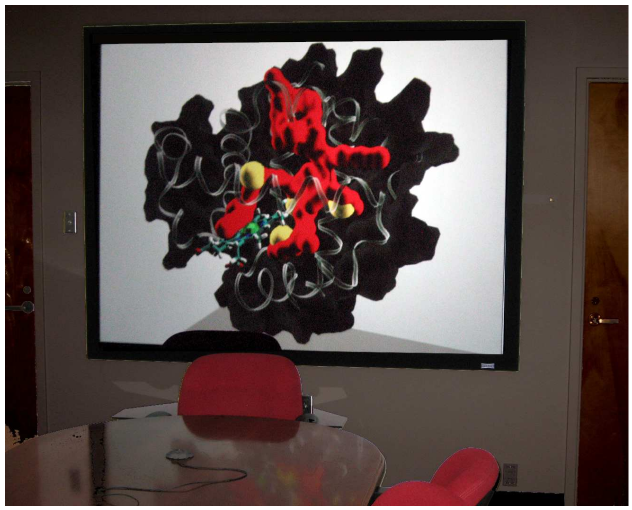
We have proposed hardware upgrades to ICTAS, ETF, and Governor's funds that will bring this valuable resource back into its rightful place as a regional and national center for immersive media development. These upgrades include a high-resolution projection system, a new low-latency tracking system, and the latest 3D acceleration cards in commodity PC workstations. As equipment is upgraded in the CAVE, it will be distributed around campus to provide additional research and instructional venues such as stereo walls and natural tracked interfaces.

ii. Stereo walls

The cost of stereo projection systems has dropped dramatically in recent years and now with commodity hardware, large-format projection systems such as interactive 3D walls are more affordable and feasible for moderately-sized labs. For visualization applications where structure, scale or spatial patterns are important, these venues provide significant productivity and insight benefits.

Passive stereo solutions provide the important perceptual cue of depth by way of 'binocular disparity' using lightweight polarized glasses. A wide range of desktop visual analytic software can be rendered from one machine in stereo with these systems. Modern projection displays provide high-resolution, large format wall-size) views for these applications.

In late winter 2007 using ETF moneys, we purchased a Viz3D system for the conference room and lab in Andrews Information Systems building (room 119). The resolution of this wall-size stereo display is 1440x1050, which provides excellent brightness and image quality for presentations and research. The system is dual-boot Linux and Windows machine with the full visual computing software stack installed.



The New Stereo Wall in Andrews 119

A number of similar stereo wall screens and projection harnesses are or will be in operation at labs and departments this year: Biology, Art & Architecture, Civil Engineering. Most recently, an active stereo wall with ultrasonic tracking (the Fakespace ROVR) was setup in Torgersen 3050. These additions provide faculty and students multiple opportunities to take advantage of immersive displays for large or complex digital environments

iii. Spectra server

Spectra is the name of a visualization gateway to System X installed in Spring 2007. This machine can serve supercomputer data and visualizations over the web and has a number of advantages over traditional architectures. Like standard web servers, the machine employs programs to transform data into alternative formats for publication and distribution. Unlike standard web servers, Spectra is also a real-time rendering server meaning that it can generate visualizations for distributed and thin clients. This approach, in use by major national labs, is especially advantageous when the data is a prohibitively large to move or process in bulk.

iv. NCR planning

We have provided specifications for a large-format, high-resolution visualization venue in the North Capitol Region of Virginia in the new VT building in Ballston, VA. This venue would provide an arena for public, VIP and sponsor demonstrations. It will also serve as an immersive, interactive visual interface to any HPC systems resident there, at VT, or on the high-speed network. Plans for budget, space, and support are pending approval.

c. *Software Infrastructure*

In the last Eight months, we have surveyed, collected, formalized, and installed a core base of software that serves a majority of users across campus. Across departments, we identified the top tools and data formats in use for domains as varied as: Physical and Bio chemistry, CAD, Fluid Dynamics, and GIS. These tools include web and back-end services for visualization middleware (such as file format conversion and composition of interactive 3D environments) and front-end interfaces for visualization clients for the desktop, stereo wall, and CAVE platforms.

Due to the variety or user requirements for visualization, one size does not fit all. We have therefore focused on developing interchangeable capabilities such as support for international standards such as VRML and X3D. In addition, we have participated with the Naval Postgraduate School and NIST in the development of open source solutions. Support for some commercial packages that require licensing (e.g. Amira) are desired by HPC faculty, but no budget exists. Future work includes expanding capabilities and compliance of the software stack.

3. Adoption

The principle approach to driving adoption of best-of-breed visualization technology relies on the education of faculty and student users. We have made significant progress in disseminating tools and methods to VT users through formal classes and consultation with various research groups.

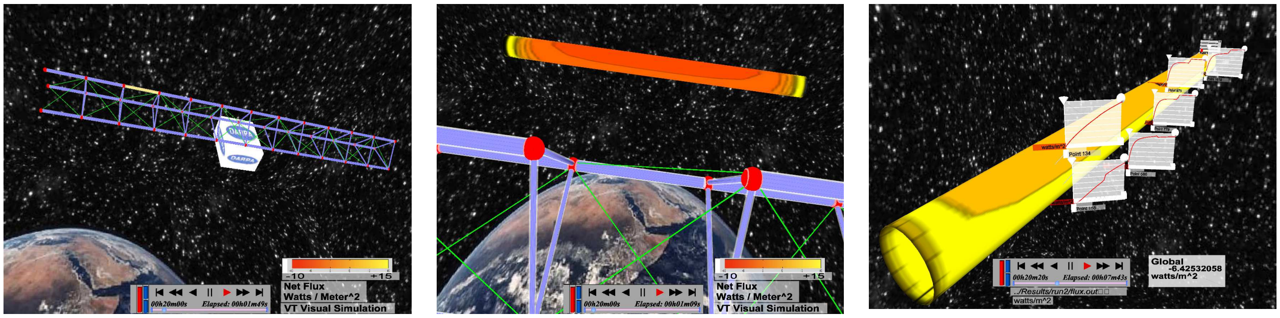
a. Faculty

i. FDI

In Spring and Summer 2007, the Visual Computing PostDoc ran an FDI track called **Deep Media for Research and Education.** Beginning with an introduction and overview to Deep Media, participants in this track learn the various ways Deep Media content can be delivered through the presentation of examples from a variety of disciplines. The pros and cons of Deep Media in research and education are outlined early in this track. From this introduction, participants learn to use various tools which assist with 3D graphics publishing, modeling and animation. Visualization design techniques are explored and include an overview of recent research into human perception and cognition that informs design choices. An overview of the creation process of dynamic, scripted 3D environments, and immersive environments (e.g., stereoscopy, large screens, and CAVE technology) concludes this track. Any media / computer-savvy faculty member will be able to be productive in this track; however, as it progresses, a knowledge of client-side (e.g., Java, ecmascript, etc.) and server-side (e.g., Perl and PHP) technologies will aid in understanding but are not required of all participants. Upon completing this track, participants will be able to plan and execute basic interactive visualization and 3D content production. Between the two offerings of this class, over a dozen faculty from multiple colleges have successfully completed this training.

ii. ***Projects***

Through consultation and project development, we have provided expertise and solutions for projects in the following departments: CS, Math, Biochemistry, Physics, Plant Pathology, Building & Construction, Architecture, Art & Art History.



ICAM DARPA Project: Movie & Vis Processing Framework

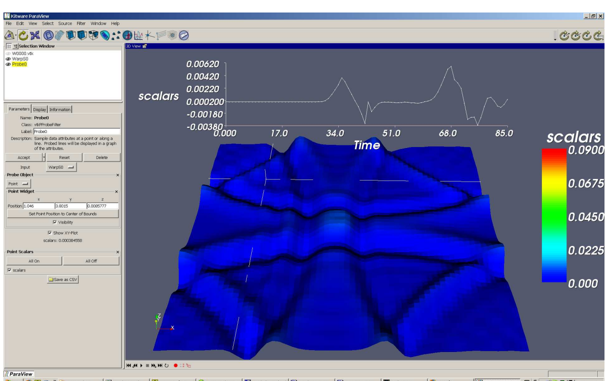
b. *Students*

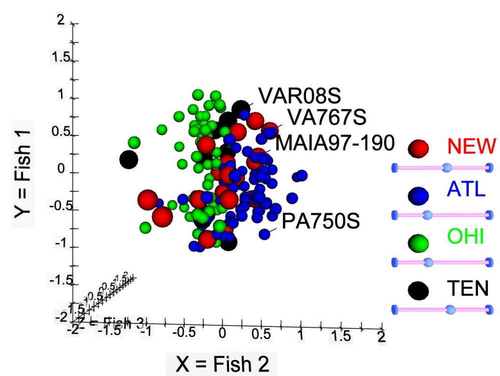
i. *GEDI*

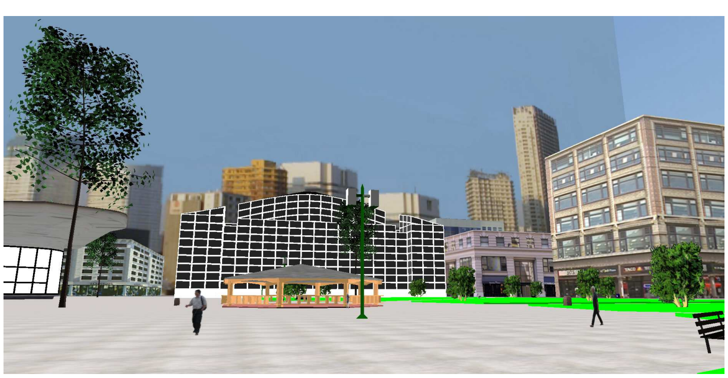
We participated in the planning and execution of a pilot program through the Graduate School focusing on skill sets for **Workshop in Computational Science**. With a team-taught format, Dr. James Turner, Dr. Nicholas Polys, and Dr. Cal Ribbens ran a two credit evening class that gave students basic applied understanding of simulation tools, visualization tools, and workflow.

ii. ***Projects***

Through consultation and project development we have provided expertise to graduate students and their projects from CS, Civil Engineering, Mechanical Engineering, Fisheries & Wildlife Science.







Enabling Student Visualization Projects at VT

4. **Leadership**

Through the Post-Doctoral position and VT's continued membership in the Web3D Consortium, Dr. Nicholas Polys has continued to lead and advance international standards for networked, interactive 3D environments. As an elected member of the Board of Directors, Dr. Polys has helped guide the organization in recent successes including new members and effective liaison relationships with medical imaging standards groups (DICOM), game physics standards groups (COLLADA) and geospatial standards groups (OGC).

Dr. Polys is an active contributor to these industry-standard specifications. In the X3D Specification Working Group, he has provided key contributions in the area of text rendering and programming interfaces. As Co-chair of the User Interface Working Group, Dr. Polys is applying his experience in 3D user interfaces and human computer interaction to open up the scene graph to multiple input devices and output displays. Finally, as Web3D representative to DICOM, he has contributed to the next-generation 3D mesh description for medical imaging devices. By participating in industry efforts such as Web3D standardization, we have continued to advance VT's leadership in cutting-edge technologies.

5. **Recognition**

a. Facility Tours

While the current mandate and budget for the CAVE facilities does not include outreach activities, we have done our best to meet the communities' needs on this regard. In any given week there are multiple requests from all over campus and the state and with current resources we cannot accept them all. Based on case-by-case judgment, we have provided some tours including current and prospective faculty and students. In March 2007, we assisted in hosting the Structural Biology Symposium at Virginia Tech and included CAVE tours for attendees.

b. **Conferences & Publications**

i. SuperComputing 2006

In November 2006, we attended SC in Tampa, FLA. Virginia Tech has a strong presence at the conference with a booth and multiple papers being presented. Dr. Polys of Research Computing assisted with the booth planning as well as video examples and a presentation on visualization at VT. This trip was productive for VT recognition, but also for education of our team. For example, the Workshop on Ultra-Scale Visualization was an excellent venue to discover and discuss how next-generation tools will meet the challenges of terra-scale and peta-scale computing.

ii. IEEE VR 2007

Dr. Polys was an important member of the 2007 Program Committee, serving as Workshops Co-chair. He also organized a workshop with other leading international experts entitled "Future Standards for Immersive VR". His contribution to this workshop included the position paper:

> **Polys, Nicholas F**., "Parallel Realities? The Requirements of Web3D and Immersive VR". Workshop on Future Standards for Immersive VR, *Proceedings of IEEE Virtual Reality*, IEEE Press. 2007.

Dr. Polys was also a panelist on the NSF-sponsored student panel: "Building the Future of and a Career in VR", which received outstanding ratings from attendees.

iii. ACM / Eurographics Web3D 2007

For the twelfth annual Web3D Symposium, Dr. Polys served as Program Co-chair. The conference this year has an exciting variety and depth of topics. In addition, he is an invited participant for a panel on Scientific Visualization and a paper presenter. The paper describes our work done on the software middleware for simulation visualization:

Polys, Nicholas F., Shapiro, Michael., Duca, Karen, "IRVE-Serve: A Visualization Framework for Spatially-Registered TimeSeries Data". *The Web3D 2007 Symposium*, ACM SIGGRAPH, 2007.

iv. Journals

Dr. Polys' research on perceptual cues and display size in Information-Rich Virtual Environments is beginning to make it into CS and Graphics journal publications:

Polys, Nicholas F., Kim, S., Bowman, D.A. "Effects of Information Layout, Screen Size, and Field of View on User Performance in Information-Rich Virtual Environments." *Computer Animation and Virtual Worlds* 18:1, 2007.

Dr. Polys was also lead or co-author on a number of journal papers submitted in the last six months including:

Polys, Nicholas F., Bowman, D.A., and North, C., "The Role of Depth and Gestalt Cues in Information-Rich Virtual Environments" *International Journal of Human-Computer Studies*, Elsevier (submitted 3/2007)

D.A. Thorley-Lawson, V. H., K. Luzuriaga, A.S. Jarrah, R. Laubenbacher, K. Lee, **N.F. Polys**, E. Delgado-Eckert, M. Shapiro, K.A. Duca, "A Virtual Look at Epstein-Barr Virus Infection: Biological Interpretations". *PLOS Pathogens*. (submitted 2006)

M. Shapiro, K. A. D., K. Lee, E. Delgado-Eckert, A.S. Jarrah, R. Laubenbacher, **N.F. Polys**, V. Hadinoto, D. Thorley-Lawson, "A Virtual Look at Epstein-Barr Virus Infection: Simulation Mechanism". *PLOS Pathogens*. (submitted 2006)

Yost, Beth, Saraiya, P., **Polys, N.F**., and North, C. "A Hierarchical Design Space for Visually Integrating Spatial and Multidimensional Data" *International Journal of Human-Computer Studies*, Elsevier (submitted 3/2007)

6. Funding Efforts

a. Internal

We have worked diligently to alert and educate stakeholders in our new activities behind visualization. We have had communication with a number of Department heads, Deans, the Research Division, and ICTAS. While we were unable to garner significant financial support, we received positive verbal encouragement. We hope to translate these good intentions into real action and support for a comprehensive plan.

b. External

We completed an early-phase software project for the Naval Postgraduate School. A number of proposals have been generated to date; one SBIR and two NSF proposals were not funded. Two additional NSF proposals are still pending with Dr. Polys as Co-PI:

- One add-on to the NSF MILES-IGERT ISE grant, "Thrive! A Radical Approach to Living Well"
- One NSF CCLI Phase 2 "Integration of Visualization with Structural Systems Understanding to Improve Technical Educatiosn of Architects"

We are currently planning and positioning for a large-scale NIH submission this year concerning the integration of visual informatics, protein structure, and molecular dynamics.

7. Future Goals

In this first year, we have demonstrated the value of visualization development and operations for VT to be a world-renown innovator in Visual Computing. To be truly successful and compete with top-tier institutions, we believe is essential to have sustained commitment from the University administration and community as well as federal funding agencies. The organizational structure of Virginia Tech has been a challenge for our goals of open access. For example, visualization capabilities cut across research, education, and outreach activities. While we have proven that our approach meets a broad-based need and we have engaged stakeholders obtaining consensus and investment from multiple parties has proven a difficult task. Indeed at the current level of support, we are at a bare-bones survival budget: if equipment breaks, that functionality goes off line.

The most positive outcome would be administrative support for a comprehensive visualization plan that leverages VT's expertise and resources. By funding staff, overhead, and maintenance costs, we can provide the community with demonstrated solutions that are on par with other nationally-ranked institutions. For example, strategic investments will allow reliable access to facilities and a scaling of visualization consulting and development services.