AC 2007-395: VISUALIZATION CENTERS AND TECHNICAL CURRICULA

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Visualization Centers and Technical Curricula: A Proposal for Study

Abstract

This paper proposes to study how activities of technology-intensive visualization centers have or have not been integrated into technical undergraduate curricula. The study focuses on visualization centers applied to urban planning, engineering, construction, medicine, and science. The study is delimited and a set of preliminary research questions are proposed.

Introduction

Data visualization has become an important tool in science, engineering, and technology education and practice.[1] Technologies for interacting with complex multi-dimensional data have become economically feasible and functionally practicable as witnessed by the establishment of "Visualization Centers" at a number of university locations. Indeed, visualization technologies have become sufficiently mature that most, if not all, technical problems in delivering visualization functionality have been solved. Still, many questions concerning curricular implementation persist.

There have been industrial initiatives by technology providers—such as EON Reality of Irvine, California (www.eonreality.com)—to focus visualization tools on academic activities.[2] Through their sponsored Interactive Digital Centers (IDC), EON provides a model for evaluating visualization technologies as well as how they may be integrated into technical curricula. Other technology providers such as FakeSpace (www.fakespace.com) have also made inroads in introducing visualization technologies at university locations.[3]

A number of funding models exist for these visualization centers, both for initial startup and continuing support. These models reflect unique local legislative, economic, and educational factors: state appropriations, internal institutional funds, one-time economic development funds, sponsorships by technology providers, partnerships (industry, military, and government), and ongoing funding through research grants (NSF, NASA, DOD). For example, the Center for Visualization and Virtual Environments in the state of Kentucky (www.vis.uky.edu/) has used a combination of public and private funds to establish their facility.

Visualization techniques such as modeling, simulation, video imaging, and virtual reality allow students who otherwise would find it difficult or impossible to understand complex visual relationships the opportunity to directly interact with numerical, graphical, and conceptual data.[4, 5, 6] Graduates of the technical professions previously mentioned—science, engineering, and technology— with the addition of medicine, law, and the social sciences, make use of data visualization to an increasing extent.[7]

In fact, use of these tools changes not only the way problems are solved, but alters the manner in which problems are identified, prioritized, and eventually explained to a broad spectrum of the population.

Statement of the problem

Although a number of universities have recognized the potential of these data visualization tools in understanding problems based on complex data (see the list of visualization centers listed elsewhere in this paper), there has been a perceived disconnect between establishing a facility that demonstrates the viability of visualization technologies and the actual integration of visualization technologies within curricula.[8] This is not a unique situation in the history of digital technology maturation. Almost every digital technology has gone through stages culminating in an “island” or “silo” of technology. What has happened after that point has determined, in large part, how imbedded that technology has become in professions, education, and society in general.

The current model for implementing visualization techniques has taken on the form of a dedicated, geographically and administratively removed entity. It is interesting that this approach follows how new (and often expensive) technologies have been implemented in the past in higher education. Some may remember when even electronic calculators were housed in dedicated “computing laboratories.”

It is general practice to implement visualization technologies in a centralized and dedicated “center,” a facility separated physically, intellectually, and pedagogically from academic enterprises that might use it best. This is not because visualization is a new, recently discovered technique. Literature on data visualization spans several decades—from the time where visualization activities required significant and dedicated computing facilities and proprietary software, to distributed and collaborative visualization using inexpensive yet powerful desktop computers.[9, 10, 11]

Currently, visualization technologies are at a critical crossroad. Will data visualization remain the provenance of an elite few or will structures and approaches arise to distribute its functionality to those who can best make use of its potential? It is the modern equivalent of the 1990's centralized versus decentralized computing conflict.

In this author's opinion, it is not a question of *if* current visualization activities are introduced into the day-to-day activities of technical curricula, only the matter of *when* and *how*. By using existing visualization centers as case study exemplars, the following research question can be asked:

What lessons have been learned by current adopters of visualization technologies that would increase their successful integration into undergraduate curricula in science, engineering, and technology education?

Investigation delimitations

Most technological issues concerning how visualization technologies are evaluated, purchased, installed, and maintained have been solved. The technology is mature. For these reasons, an investigation into visualization technology implementation can be delimited by stating that the study:

1. Would not investigate how visualization centers are funded, other than in how such funding positively or negatively impacts integration of center technologies into academic programs.
2. Would not investigate how visualization technologies are configured, other than in how such configurations positively or negatively impact integration with academic programs.

3. Would focus on how visualization technologies are integrated in day-to-day educational activities in science, engineering, and technology.

4. Would report how existing efforts at other universities have/have not been effectively integrated into curricula applicable to Arizona State's Polytechnic Campus.

Preliminary questions to be addressed

Much of the sabbatical investigation will be devoted to identifying where and how visualization technologies have been effectively integrated into curricula parallel to those at the Polytechnic Campus. It may be more significant to identify cases where visualization technologies *have not* been effectively integrated into curricula. Preliminary questions include:

1. Were representatives from interested academic programs involved in the original planning of visualization facilities and if so, how?
2. If interested representatives were not involved in the planning of visualization facilities, what have been the ramifications?
3. If organized as a center, is there an established mission statement? Are there identified outcomes and methods established to assess them?
4. If not organized as a center, how can the organization be characterized and how is its effectiveness evaluated?
5. What was the funding model for the initial effort to acquire visualization technologies?
6. What funding models exist for the continuation of visualization technologies, especially in curricular integration?
7. What mechanisms exist to promote the capabilities of the available visualization technologies?

8. What mechanisms, if any, exist to assure that undergraduate students have access to the functionality of visualization tools at your institution?
9. What are examples of success in your visualization efforts? How is success accessed?
10. What are examples of failure in your visualization efforts? How is failure corrected?
11. What would be done differently if embarking on a new effort to integrate visualization techniques on your campus?

Visualization centers identified for study

Arizona State University
Decision Theater
http://dt.asu.edu/index.html
R.F. Shangraw, Jr., Executive Director
Rick.shangraw@asu.edu

Brown University
Graphics and Visualization Center
http://www.cs.brown.edu/stc/home.html
Andries Van Dam, Senior Investigator
avd@cs.brown.edu

University of California at Berkeley
Video and Image Processing Laboratory
Avideh Zakhor, Director
avz@eecs.Berkeley.edu

Carnegie Mellon University
The Sage Visualization Group
Steve Roth, Senior Research Scientist
Director, Visualization & Intelligent Interfaces Lab
roth+@cs.cmu.edu

Duke University
Levine Science Research Center
Center for Interdisciplinary Engineering, Medicine, and Science (CIEMAS)
http://vis.duke.edu/
Rachael Brady, Director
rbrady@duke.edu

University of Kentucky
Center for Visualization and Virtual Environments
http://www.vis.uky.edu/
Dr. Brent Seales
seales@netlab.uky.edu

University of Minnesota
Super Computing Institute for Digital Simulation and Advanced Computation
http://www.msi.umn.edu/user_support/scivis/
Andrew Odlyzko, Director of the Digital Technology Center
odlyzko@dtc.umn.edu

Pennsylvania State University
The GeoVISTA Center
http://www.geovista.psu.edu/
Alan MacEachren, Director
maceachren@psu.edu

Purdue University
Envision Center for Data Perceptualization
Gary Bertoline. Associate Vice President for Discovery Resources
Director of Envision Center
bertolig@purdue.edu

References

[1] Owen, G. Scott. *Visualization Education in the USA*. IFIP WG 3.2 Working Conference on Informatics at the University Level (1991).

[2] Temasek Case Study. "Polytechnic Case Study V.O.L.U.M.E. (Virtual Object Library Universal management Environment). Accessed January 9, 2007 from http://www.eonreality.com/case_studies/temasek/index.html.

[3] FakeSpace. "FakeSpace Provides Advanced Collaboration Environment to University of Salford." Accessed December 16, 2006 from http://www.fakespace.com/press.htm.

[4] Clark, Aaron C., and Matthews, Brian. "Scientific and Technical Visualization: A New Course Offering that Integrates Mathematics, Science and Technology." *Journal for Geometry and Graphics*, Vol. 4, No. 1, pp. 89-98 (2000).

[5] Clark, Aaron C., Wiebe, Eric N., and Hasse, Eleanor E. *Scientific Visualization: A New Basic in Design and Technology*. Presented at the Design and Technology Association

[6] Domik, G., Editor. *Curriculum for Visualization.* ACM SIGGRAPH Curriculum for Visualization On-Line Document. Accessed August 31, 2006 at http://wwwcs.uni-paderborn.de/fachbereich/AG/agdomik/visualisierung/vis-report/index.htm.

[7] University of Illinois at Chicago. *Curriculum in Biomedical Visualization*. Accessed August 31, 2006 from http://www.ahs.uic.edu/bhis/programs/bvis/curriculum.php.

[8] Naps, Thomas, Rodger, Susan, and Rössling, Guido. *Animation and Visualization in the Curriculum: Opportunities, Challenges, and Successes*. Technical Symposium on Computer Science Education (2006).

[9] Richards, Larry G. *Incorporating 3D Modeling and Visualization in the First Year Engineering Curriculum*. ASEE/Frontiers in Education Conference (1995). Accessed August 31, 2006 from http://fie.engrng.pitt.edu/fie95/3c5/3c55/3c55.htm.

[10] Doering, Edward R. *Scientific Visualization in the Circuits Curriculum: Enhancing Student Insight.* ASEE Frontiers in Education Conference (1995). Accessed from http://fie.engrng.pitt.edu/fie95/2c6/2c63/2c63.htm.

[11] Rotard, Martin; Weiskopf, Daniel; and Ertl, Thomas. *Curriculum for a Course on Scientific Visualization*. Eurographics / ACM SIGGRAPH Workshop on Computer Graphics Education (2004).