Information and Scientific Visualization: Separate but Equal or Happy Together at Last

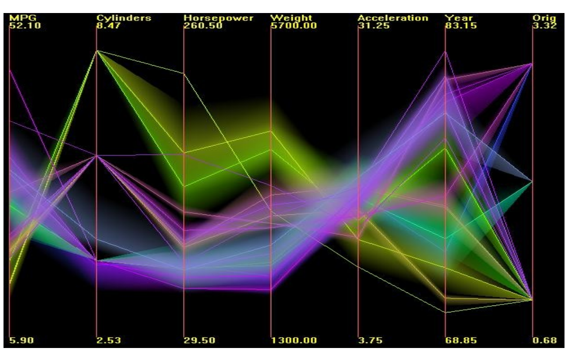
Panel Organizer & Presentor:
Theresa-Marie Rhyne, North Carolina State University

Panelists:
Melanie Tory, Simon Fraser University
Tamara Munzner, University of British Columbia
Matt Ward, Worcester Polytechnic Institute
Chris Johnson, University of Utah
David H. Laidlaw, Brown University

INTRODUCTION:

Must we continue to define a difference between information and scientific visualization? Scientific visualization evolved first in the late 1980's while information visualization matured in the mid-1990's. Scientific visualization is frequently considered to focus on the visual display of spatial data associated with scientific processes such as the bonding of molecules in computational chemistry. Information visualization examines developing visual metaphors for non-inherently spatial data such as the exploration of text-based document databases. This panel examines the effective, productive, and perhaps confusing tension between these subfields of visualization by highlighting the following issues:

- Does this tension provide useful mechanisms for advancing the global field of Visualization or is it creating confusion?
- Is there a need for a new subfield classification scheme?
- Should we continue the separate but equal approach that has been effective in the past?



Information Visualization image shown courtesy of Matt Ward of Worcester Polytechnic Institute (WPI).

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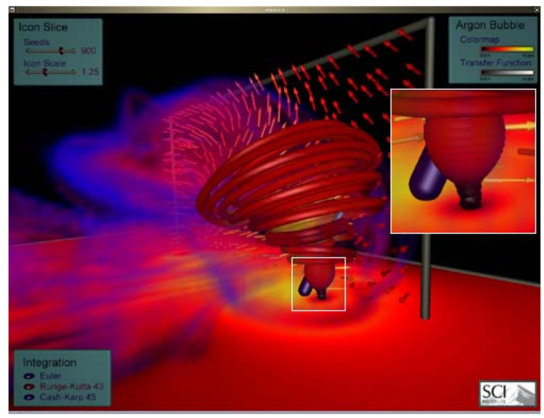

Scientific Visualization image shown courtesy of the Scientific Computing and Imaging Institute of the University of Utah.

POSITION STATEMENTS:

The Panel Organizer's Viewpoint

Theresa-Marie Rhyne:

As a visualization designer, my choices and applications of spatializations straddle both the scientific visualization and information visualization arenas. My early work in environmental sciences visualization encompassed visualizing geographically registered data from weather models. While these were scientific visualization problems, we quickly realized the importance of implementing cartographic and information visualization techniques to assist in examining environmental policy issues associated with scientific results. Today, as I work with genomic and bioinformatics researchers, I continue to float between interactive data mining visualization techniques and the interactive virtual immersion methods of scientific visualization. I think it would be clearer to genomic and other investigators if we focused on the various types of visual display and visualization methods applied rather than specifying if we are speaking in terms of information or scientific visualization. My viewpoint is that there is a need for a new subfield classification scheme. A scheme that establishes categories based on the type of spatialization techniques being applied. We can continue with the separate but equal approach that has been effective in the past but it does cause confusion when helping investigators understand how to apply visual display techniques to their specific data and information.

A New Classification Scheme Viewpoint

Melanie Tory:

My research interests are in human interface aspects of visualization. Although I currently focus on volume data (traditionally considered "scientific visualization"), I find many interesting ideas and human factors approaches in the "information visualization" area. As such, my research interests do not fall squarely within one subfield or the other, and it is important to me to clarify how they relate. A traditional definition is that "scientific visualization is visualization applied to scientific data, and information visualization is visualization applied to abstract data…scientific data are often physically based, whereas business information and other abstract data are often not" [Card et al. 1999]. This common classification scheme is simple but can also be vague and confusing. For example, abstract mathematical functions (e.g., $f(x) = 2^x$) and purity results from a chemistry experiment are scientific but not physically based. Similarly, air traffic control systems are physically based, but not necessarily scientific. Is visualization in these domains "information visualization" or "scientific visualization"?

In [Tory and Moller. submitted], we proposed a new classification scheme that organizes visualization techniques in a new way. The new taxonomy is based on characteristics of models of the data rather than on characteristics of the data itself. "Continuous model visualization" encompasses all visualization algorithms that use a continuous model of the data (i.e., the algorithm assumes that the phenomenon being studied is continuous, even if the data values are discrete), and is roughly analogous to "scientific visualization". "Discrete model visualization" includes visualization algorithms that use discrete data models and roughly corresponds to "information visualization". For example, meteorological visualizations display atmospheric conditions such as temperature, pressure, and wind direction. Continuous models of meteorological data can be visualized using continuous techniques such as streamlines and isosurfaces. Alternatively, weather conditions in major cities can be visualized using icons on a map (a discrete visualization). These new categories are less ambiguous than previous classification schemes and may help us better organize visualization literature and ideas.

Card, S.K., Mackinlay, J.D., and Shneiderman, B. 1999, *Readings in Information Visualization: Using Vision to Think*, Morgan Kaufmann Publishers, San Francisco, 6-7.

Tory, M. and Möller, T., "A Model-Based Visualization Taxonomy" (submitted).

Information Visualization Viewpoints

Tamara Munzner:

I do defend the continued "separate but equal" evolution of infovis and scivis as two distinct subfields, at least for the next few years. Although there are still many definitions of infovis floating around, I think we have begun to converge on the answer that the dividing line is whether the spatialization is given or chosen. The current names are rather unfortunate accidents of history: scientific visualization isn't uninformative, and information visualization isn't unscientific. However, it's been over a dozen years since the term "information visualization" was introduced, and at this point I think it would be more confusing to change the names than to keep them.

The fact that the two fields have been at least somewhat separated is arguably also a historical accident. This history is precisely why they should stay separated for a while: by now, they are judged by rather different criteria. The central design problem of an infovis system is the choice of how to assign spatial position, which is by far the strongest of the perceptual cues. Our grappling with this huge space of possibilities has led to a strong emphasis on abstraction, visual metaphors, design principles, and evaluation. On the flip side, we lag behind scivis in areas such as the scalability of our algorithms to huge datasets, and the adoption/commercialization of our ideas by the intended audience of people outside the research community. I believe that the divergence of these review criteria has allowed the frontiers of each field to expand faster than they would if combined, and that there is still a lot of room for each area to explore before their borders become thoroughly entangled.

Although it's quite possible that these two subfields will merge in the next five to ten years, I can also envision a very viable future where the two fields maintain cordial relations but follow increasingly divergent intellectual paths. On the practical level, although a small number of people have one foot in each subfield, the reviewing communities for the InfoVis symposium vs the Vis conference are currently largely distinct. The first separate InfoVis symposium in 1995 was necessarily a weaker venue than Vis 95, but the number of submissions and the quality level has risen monotonically every year. Last year's acceptance rate for papers was a respectable 27%. Although we are still smaller in size, in my opinion our selectivity is now on par with Vis, and we are justified in claiming equality.

Matt Ward:

It is clear that Information and Scientific Visualization share a common goal, namely visual communication for the purpose of the presentation and exploration of data, concepts, relationships, and processes. There are many ways of looking at the field. From one view we can differentiate techniques based on the structure and type of data being examined; is it nominal or ordinal, scalar or vector? Another view separates methods based on whether you are looking at data values or relationships. Thus a text visualization tool might highlight the content of a text document or the relationships between a set of documents. Yet another way to decompose the field is by the visualization pipeline - are we interested in optimizing or scaling rendering algorithms/techniques or are we more interested in the perceptual or user interaction end of things? Finally, we can divide the field up based on the domain of the data or information; are we visualizing medical data, software, genetic sequences, remotely sensed data, internet traffic, fluid dynamics models, or whatever. Given the different views, we might ask how SciVis and InfoVis define themselves?

An examination of the sessions from the Visualization and Information Visualization proceedings over the past 5 years is quite revealing. Some topics, such as flow visualization or hierarchy navigation, only appear in one of the venues, while other topics, such as visualization frameworks and large-scale visualization, as well as application areas such as biomedicine, can be found in both. However, I would argue that most, if not all, visualization techniques, interactive tools, and evaluation methodologies being reported at these conferences could find application in both the InfoVis and SciVis communities. The same could be said to be true for issues such as scalability and visual perception. So what is the cause of the separation? Why do some people attend InfoVis but not Vis (and vice versa)?

For me, I notice that I often attend nearly all the talks at InfoVis, but sometimes find myself interested in none of the parallel sessions at some point during the Visualization conference. Algorithm variations don't excite me - one isosurface or simplification algorithm is the same as the next to me. I'm interested in papers with a higher novelty factor: new ways to look at data or information, new ways to interact with the visualization, new theories about why some visualizations work better than others. These seem to be taking place more frequently in the InfoVis community, in my opinion. New application areas also tend to open things up to innovation, even if it is customizing an existing method to work with new types of data or for new purposes. Thus I often find myself drawn to talks on new domains for visualization rather than what I perceive (perhaps wrongly!) as incremental refinements to existing methods. Now it may seem to some that InfoVis is starting to drift towards the incremental, as we see more and more variants on tree visualization and navigation (some of my work is included in this) as well as other popular topics. However, I think there has yet to be presented a really adequate and effective solution to some of these visualization challenges.

My belief is there will always be separations based on the evolution of different subfields and the number of researchers focused on particular issues, but these separations are really artificial. There are different audiences - SciVis is perhaps more heavily populated with people from the traditional graphics field, while InfoVis has a much stronger mix from the HCI community. However, everyone would benefit from having exposure to the entire spectrum of the field, and thus I'd prefer we grab onto and emphasize the common force between SciVis and InfoVis rather than try to force a separation that, in my mind, would have little benefit.

Scientific Visualization Viewpoints

Chris Johnson:

Merging Scientific and Information Visualization for Data Intensive Science Applications

The amount of information available from large-scale simulations, experiments, and data collection to scientists today is unprecedented. In many instances, the abundance and variety of information can be overwhelming for scientists and engineers. The traditional method for analyzing and understanding the output from large-scale simulations and experiments has been scientific visualization. However, increasing amounts of scientific information collected today has high dimensionality and is not well suited towards traditional scientific visualization methods. To handle high dimensional information, so-called information visualization techniques have been developed and there is a growing community of information visualization scientists. Curiously, the information visualization and scientific visualization communities have evolved separately and, for the large part, do not interact. As such, a significant gap has developed in analyzing large-scale scientific data that has both scientific and information characteristics.

The Scientific and Information Visualization Challenge

The time has come to break down the barriers that currently exist between information and scientific visualization communities and work together to solve problems significant scientific importance. The goal is to create integrated visualization and analysis capabilities that use the best of information and scientific visualization research techniques and to create new integrated "scientific-information" visualization software systems. A specific example where scientific and information visualization techniques could have an immediate positive benefit to the application scientist is in analyzing, understanding, and representing error and uncertainty in complex three-dimensional simulations. It is understood that there is error and uncertainty in all phases of simulation science, in representing the discrete geometry, in approximating the governing physical equations, and in visualizing the results. However, little has been done to effectively analyze and represent these errors and uncertainties. Given the strength of geometric representations of scalar, vector, and tensor fields via scientific visualization and the representation of statistical information from information visualization, the analysis and representation of simulation error and uncertainty would be a way to more effectively understand the big picture of the simulation results in more complete way than either scientific visualization or information visualization methods could do independently.

David H. Laidlaw:

My initial reaction to Theresa-Marie Rhyne's question for this panel was: why are we wasting time on this? But as we talked, and as I subsequently pondered, I realized that there may be some less-than obvious issues. As far as differences, scivis problems typically have an intrinsic spatio-temporal interpretation while infovis problems do not; fluid flow and MRI volumes live in our 3D geometric world, but there is no intrinsic geometric space for the members of a large corpus of documents. There are also similarities between infovis and scivis. The ``vis'' at the end means that both can benefit from design, from perceptual psychology input, from application feedback, and from scientific testing.

I don't believe that either these differences or similarities speak to the question of whether the areas should be merged; certainly, they could be. My sense is that the benefits of splitting or merging come from the social implications of the size and homogeneity of the attendees of each venue. Visualization is bigger, older, more selective, more heterogeneous, and, dare I say, a bit stodgier and less creative. Infovis is smaller, younger, less established, more homogeneous, and more novel and creative. All that being said, I typically value Vis over Infovis because I think geometrically and can bring that to bear on scivis problems. It would be a shame, I think, to lose the energy at Infovis that comes from the focus of the problem area, it's youth, and the relatively small group of participants.
It's good for at least a few more years!

BIOGRAPHICAL SKETCHES FOR PANELISTS:

Theresa-Marie Rhyne: (tmrhyne@ncsu.edu)

Theresa-Marie Rhyne is a multimedia and visualization expert in Learning Technology Service at North Carolina State University. In January 2002, she began contributing to the NC BioGrid effort (http://www.ncbiogrid.org) under development at the North Carolina Supercomputing Center/ a division of MCNC. From 1990 - 2000, she was a government contractor (initially for Unisys

Corporation (1990 - 1992) and then for Lockheed Martin Technical Services (1993 - 2000)) at the United States Environmental Protection Agency's (US EPA) Scientific Visualization Center. She was the founding visualization expert at the Center. She was the Lead Conference Co-Chair for IEEE Visualization 1998 and the Past Conference Co-Chair for IEEE Visualization 1999. She serves on the Editorial Board of IEEE Computer Graphics & Applications (IEEE CG&A) and is editor of the Visualization Viewpoints department for IEEE CG&A. She is also a senior member of IEEE. Her specialties include streaming media, internetworked 3D computer graphics, the application of art techniques to visualization, collaborative-networked visualization, environmental sciences visualization, geographic visualization and, most recently, bioinformatics visualization.

Melanie Tory: (mktory@cs.sfu.ca)

Melanie Tory is a PhD candidate in the Graphics, Usability, and Visualization lab at Simon Fraser University. She received a BSc degree from the University of British Columbia in 1999. Her research objective is to enhance the value of visualization tools by developing and evaluating effective user interfaces. She has interests in both continuous and discrete model visualization and is currently exploring ways to combine 2D and 3D views for visualization of spatial data.

Tamara Munzner: (tmm@cs.ubc.ca)

Tamara Munzner became an assistant professor of computer science at the University of British Columbia in Vancouver in the summer of 2002. Her current research interests are information visualization, graph drawing, and interactive computer graphics. She is particularly interested in creating scalable algorithms, both in the size of the dataset and the number of display pixels. She has designed visualization systems for a wide variety of domains, including computational linguistics, topology, networking, and web site design.

The domains of her current projects include bioinformatics, data mining, and the integration of semantic networks with geospatial data. From 2000 until 2002 she was a research scientist at Compaq Systems Research Center in Palo Alto, California. She completed her PhD in computer science at Stanford University in June 2000, where she also received a BS in computer science in 1991. Between 1991 and 1995 she was a member of the technical staff at the University of Minnesota Geometry Center, with the research focus of mathematical visualization. Her projects included the Geomview system for flexible interactive 3D visualization, and expository computer animations on topics such as how to turn a sphere inside out, or spaces that are finite but have no boundary. She has consulted for Silicon Graphics Inc, Microsoft Research, and the supercomputer company ETA Systems. She is Program Co-Chair of the 2003 IEEE Symposium on Information Visualization, and was Posters Co-Chair in 2002 and 2001.

Matt Ward (matt@wpi.edu)

Dr. Matthew Ward is presently a Professor of Computer Science at Worcester Polytechnic Institute (WPI). He received his B.S. degree in Computer Science from WPI in 1977 and his M.S. and Ph.D. in Computer Science from the University of Connecticut in 1979 and 1981, respectively. Prior to joining WPI in 1986, he was a Member of the Technical Staff at AT&T Bell Labs in the Visual Communications Research Lab and a member of the R&D staff at Skantek Corporation. His research interests include exploratory data and information visualization, computational environments for interactive data analysis, and computer vision. He is the author or co-author of more than 60 papers in these fields, and the principal architect of several public-domain visualization packages, including XmdvTool, XSauci, SimCortex, and SpiralGlyphics.

Chris Johnson: (crj@cs.utah.edu)

Professor Johnson directs the Scientific Computing and Imaging Institute at the University of Utah where he is a Professor of Computer Science and holds faculty appointments in the Departments of Physics, and Bioengineering. His research interests are in the area of scientific computing. Particular interests include inverse and imaging problems, adaptive methods, problem solving environments, large scale computational problems in medicine, and scientific visualization. Professor Johnson was awarded a Young Investigator's (FIRST) Award from the NIH in 1992, the NSF National Young Investigator (NYI) Award in 1994, and the NSF Presidential Faculty Fellow (PFF) award from President Clinton in 1995. In 1996 he received a DOE Computational Science Award and in 1997 received the Par Excellence Award from the University of Utah Alumni Association and the Presidential Teaching Scholar Award. In 1999, Professor Johnson was awarded the Governor's Medal for Science and Technology.

David H. Laidlaw: (dhl@cs.brown.edu)

David H. Laidlaw is the Stephen Robert Assistant Professor in the Computer Science Department at Brown University. His research centers around applications of visualization, modeling, computer graphics, and computer science to other scientific disciplines. He is working with researchers in other disciplines including, archaeology, developmental neurobiology, medical imaging, orthopedics, art, cognitive science, remote sensing, and fluid mechanics to develop new computational applications and to understand their strengths and weaknesses. Particular interests include visualization of multi-valued multidimensional imaging data, comparisons of virtual and non-virtual environments for scientific tasks, and applications of art and perception to visualization. His PhD in Computer Science is from Caltech, where he also did post-doctoral work in the Division of Biology.