Getting Human-Centered Computing and Scientific Visualization Married: the Myth and Critical Issues

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Introduction — The power of scientific visualization is to represent data as graphic images that humans can understand, allowing users to execute their real-world tasks effectively. As visualization techniques become more mature, researchers have begun to tackle the human side of visualization (i.e., to study how people make use of different visualization approaches and how to build more useful and usable visualization systems). Human-centered computing (HCC) can address such concerns in many dimensions. For example, theories in cognition and perception can articulate visualization design rationales. Design methods aspire to provide frameworks ranging from low-level behavior studies to high-level task-analysis and usability evaluation. Although we are seeing great interest in the marriage of human-centered computing and visualization, the guidance for doing so is very limited. This panel brings together diverse researchers across the human-centered computing and visualization spectrum to discuss their research, to reach beyond their own fields, and to understand the marriage of HCC and scientific visualization for future collaborations.

Index Terms—human-centered computing, scientific visualization, critical issues.

POSITION STATEMENTS

JIAN CHEN

With a background in human-centered computing (HCC), I entered the scientific visualization field with a strong interest in the science of designing visualizations that help users accomplish their work effectively. I believe the marriage of HCC and scientific visualization can (1) formalize the design and evaluation of visualization techniques and systems and (2) increase the impact of scientific visualization on real-world applications. For example, visualization techniques could be improved to address differences in tasks, users, displays, contexts of use, and other factors that could affect human use of visualization systems.

In this panel, I will talk about "thinking outside visualization" and discuss the design and evaluation approaches in HCC. I will further encourage formative methods (e.g., hierarchical task analysis and claims) and prototyping tool development (e.g., low fidelity and high fidelity tools) that have presented evidence of measurable benefits.

I will ask questions about how to rate different visualization systems. To answer these questions, other important questions should be addressed: better than what techniques using what tasks and displays, for what user groups, where, and under what measurement criteria? Further, are the results reusable? In HCC, widely accepted evaluation approaches include heuristics, expert review, cognitive walkthrough, and formative and summative evaluations etc. Are these methods adequate to address the design and evaluation problems in the scientific visualization community? Or it is the underlying criteria that matter?

DAVID H. LAIDLAW

Human-centered computing and scientific visualization have some commonalities, but does perceptual psychology make our marriage metaphor into a love triangle?

My research in scientific visualization has been guided by the goals of the scientific users with whom I collaborate. In trying to address those goals through the creation of novel computational and visualization tools, my group and I have run up against a number of challenges. We have wondered how to compare different visualization methods, how to quantify ``effectiveness'', and how to determine which display form factor or interaction device is most appropriate.

Our work parallels HCC work; however, it has been developed through interactions with perceptual psychologists. The challenges above have analogues in the HCC arena, and Jian Chen articulates some of the design, prototyping, evaluation, and analysis tools developed in that arena to address the challenges. In our work, we have borrowed experimental design expertise and lore from perceptual psychology colleagues and applied it to the challenges. Abstractly, we are all doing experiments, but visualization experiments tend to be evaluating hypotheses about artifacts while psychologists tend to be evaluating hypotheses about humans. The difference leads to some subtle changes in the kinds of experiments that we do.

An HCC approach would likely lead to similar experiments and results, although perhaps couched in different terms. I hope that this panel will address the question of whether HCC provides more than a formalism for a mixture of concepts from psychology and design domains.

VICTORIA INTERRANTE

Our essential goal as visualization researchers is to devise methods for effectively conveying information through images. For many years, our primary focus, as a community, was on surmounting the basic technical challenges inherent in the implementation of methods for efficiently representing large sets of scientific data in visual form. As our field has matured, and many of the most basic challenges in rendering scientific data have been met, attention is increasingly turning to the importance of the roles of both visual design and evaluation in effectively guiding and ensuring the ultimate success of our efforts.

How can we most effectively leverage the insights and experience that fields such as perceptual and cognitive psychology, and human-centered computing, can offer? What are the challenges that we face in trying to forge mutually beneficial interdisciplinary collaborations with researchers in these fields? In this panel, I will briefly present some of my ideas and insights on these topics, based on my recent research experiences, and will discuss the progress of fledgling efforts to facilitate cross-disciplinary exchange through newly emerging multi-disciplinary venues.

WILLIAM RIBARSKY

To update Richard Hamming, "The purpose of visualization is insight, not pictures". The tasks of reasoning with data, developing insight, and creating knowledge upon which one can take action (which includes creating and evaluating a new model or theory as well as other types of actions) have become more complex and open-ended. Data are ever-growing in size, of course, but real insight often comes from looking at comprehensive, often heterogeneous data, that may have been analyzed or generated by multiple models. Decisions (for example, on hurricanes, large scale flooding, earthquakes and their aftermath, epidemic-scale disease outbreaks) must often be made in a timely manner with actions that have far-reaching consequences. In all these cases, interactive visualization should be uniquely qualified to provide critical capabilities that cannot be gotten in any other way. Since it is the interaction tightly coupled with the visualization that provides these capabilities, this is essentially human-centered computing.

Interactive visualization provides the intimate interface between the user and the data, analysis, and reasoning artifacts. Ultimately, the computer should carry out its own computations, perhaps in an agent-based framework, that augments in an essential way the human activity (while still ultimately being under human control). I argue that all of this should be under the sway of an interactive visualization system. The goal is then not to provide the best single visualization but rather to provide the optimal visual reasoning process, which will be exploratory; will involve multiple linked visualizations, with feedback and iteration; and must make use of constantly updated data and user annotations.

A new understanding of interaction is fundamental to all this. Although much work still remains to be done on the perceptual underpinnings of interactive visual interfaces, what is really missing is an understanding of how interaction supports, promotes, and even enables cognition and complex reasoning. A deep understanding, for example, must be developed for how interaction can generally support exploration and discovery, since this is often the mode for complex reasoning tasks. Effective design and evaluation for this case is much different than for the usual visual interfaces, because it must provide the intermediate visualizations that effectively and efficiently lead to discoveries when the user himself/herself doesn't know what he/she is looking for.

Some of these problems have been identified and are being pursued as part of the visual analytics research agenda [1]. However, these challenges are general and applicable to all cases where there are large scale data, extended models, and complex analyses.

BIOGRAPHIES

JIAN CHEN

Jian Chen is a research associate in the Computer Science Department at Brown University. Her research focuses on multiple-disciplinary work on visualization and human-computer interaction. She has published papers in the areas of 3D interaction in virtual environments, design theories, information-rich 3D environments, multiple-platform user interfaces, multiple-view visualization, human cognitive and perceptual abilities, large high-resolution displays, etc. These research has been applied to biology, medical imaging, architecture, and NASA space programs. She received her PhD degree from Virginia Tech and is a member of ACM and IEEE.

DAVID H. LAIDLAW

David H. Laidlaw is an Associate 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 including archaeology, developmental neurobiology, medical imaging, orthopedics, art, cognitive science, remote sensing, proteomics, genomics, 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. You can learn more about David's work at http://vis.cs.brown.edu.

VICTORIA INTERRANTE

Victoria Interrante is an Associate Professor in the Department of Computer Science and an Associate Member of the Center for Cognitive Sciences at the University of Minnesota. Her diverse research efforts in visualization and virtual environments share a common focus on the application of insights from visual perception and cognition to the development of more effective techniques for visually conveying information. She currently enjoys active interdisciplinary collaborations on various projects with colleagues from the Departments of Architecture, Aerospace Engineering and Child Development. She is a PECASE recipient (1999), an Associate Editor of the ACM Transactions on Applied Perception, and a co-founder of the ACM/SIGGRAPH Symposium on Applied Perception in Graphics and Visualization.

WILLIAM RIBARSKY

William Ribarsky is the Bank of America Endowed Chair in Information Technology at UNC Charlotte and the founding director of the Charlotte Visualization Center. He is Principal Investigator for the DHS SouthEast Regional Visualization and Analytics Center. He received a Ph.D. in physics from the University of Cincinnati. His research interests include visual analytics; 3D multimodal interaction; bioinformatics visualization; virtual environments; visual reasoning; and interactive visualization of large-scale information spaces. Dr. Ribarsky is the former Chair and a current Director of the IEEE Visualization and Graphics Technical Committee. He is also a member of the Steering Committees for the IEEE Visualization Conference and the IEEE Virtual Reality Conference, the leading international conferences in their fields. He was an Associate Editor of IEEE Transactions on Visualization and Computer Graphics and is currently an Editorial Board member for IEEE Computer Graphics & Applications. Dr. Ribarsky co-founded the Eurographics/IEEE visualization conference series (now called EG/IEEE EuroVis) and led the effort to establish the current Virtual Reality Conference series. In 2007, he will be general co-chair of the IEEE Visual Analytics Science and Technology (VAST) Symposium. Dr. Ribarsky has published over 110 scholarly papers, book chapters, and books. He has received competitive research grants and contracts from NSF, ARL, ARO, DHS, ONR, EPA, AFOSR, DARPA, NASA, NIMA, and several companies.

REFERENCES

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