Understanding Data through Collaboration

Developing Collaboration Support Tools for Expert Artists and Scientists

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INVITED EXTENDED ABSTRACT

In science, engineering, business, and even art, innovation and discovery today seem to be predicated by peoples' ability to understand complex data. Visualization is one way to achieve data understanding, and much of my research is focused on learning how to use computer graphics to present complex data to users in such a way that the human visual and cognitive systems can find meaning where automated data mining techniques cannot. One lesson my colleagues and I have learned from the users of our tools is that the interactive visualizations systems we create foster collaboration. This collaboration is repeatedly cited as one of the main benefits of the tools we create, even, to our surprise, when we have not intended for the tools to be used in a collaborative setting. This insight about the way people use data visualizations has inspired us to rethink the role of collaboration in data understanding. It also points to an exciting opportunity to combine research in data visualization with research in collaborative technologies.

The type of collaboration that has been most beneficial in our applications is expert-to-expert collaboration. Sometimes this takes the form of a team of scientists working together to analyze medical data, as shown in Figure 1. Although immersive virtual reality (VR) environments, such as this 4-wall CAVE display, are often used in a single-user mode, we find that the most interesting discoveries happen in these spaces when multiple scientists work together. When two or more people are immersed together in a large-scale virtual environment, they are presented with an opportunity for discussion that they would never have in the real world. In this example, the scientists can shrink themselves to the size of a blood cell and discuss a new design for a mechanical replacement heart valve as they view patient-specific 3D models of the human heart. This *experience* fosters a level of collaborative discussion (and perhaps even creativity) that is difficult to achieve using more traditional desktop-based and/or remote computational tools. An essential lesson for developers working with VR technologies is, therefore, to place a premium on supporting multi-user, collaborative environments. Unfortunately, this is something that is not done enough in VR systems, largely because the technology makes multi-user environments difficult to construct.

A similar style of collaborative work is also possible in smaller-scale data visualization systems. Figure 2 shows a motivating scenario: two scientists discuss the orientation of fibers in tissue imaged with a new microscopy system. Again, one of the reasons why these data are so difficult to understand is that they exist in 3D space, something that is difficult to understand when discussed over email or a videoconference. As shown in the figure, when we talk about this type of data, we naturally pick up the pen on our desk and begin to gesture

Figure 1. A Cave, 4-wall virtual reality display facilities team science by immersing scientists in their data.

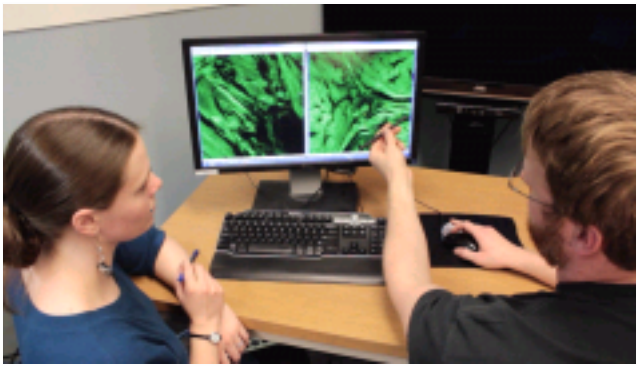

Figure 2. When scientists talk about 3D data with complex spatial relationships, they point and gesture as they talk - communication is not limited to the verbal channel.

relative to the screen, "see the fiber that goes like this··· and then curves and comes out of the screen here···" The expert communication that happens in these collaborative sessions is not just based on verbal communication but also on 3D gestures made relative to the data visualizations. In this talk, I'll demonstrate some new user interfaces we have developed to capture and respond to this type of gesture - a first step toward the scientist's desktop of the future.

Beyond scientists collaborating with other scientists, we have also explored new interactive visualization tools to help scientists collaborate with artists and other visual experts that can help design more effective visual strategies for depicting scientific data. The datasets we are now working to visualize are time-varying and multidimensional. They are extremely difficult to understand, and we do not yet know the best visual language to present the data. We have found that traditionally trained artists and illustrators have some of the most exciting, creative new ideas for how we might depict these data. However, there is a problem. The computing environments we want to use for these visualizations involve the latest and greatest technology, such as immersive VR environments that are particularly difficult to program, and most of these artists do not know how to program. So, despite their great insights and ideas, artists' practical ability to design new data visualizations is limited.

Our solution is a suite of tools that make it possible for artists to "sketch" new visualization ideas, in both 2D and 3D visualization environments, right on top of the datasets. Figures 3 and 4 shows two tools we have developed in this style. In the talk, I will describe how these tools have brought computer scientists, artists, and domain scientists together to form collaborative teams around data visualization problems, and how critique and other collaborative artistic traditions play a role in these interdisciplinary interactions.

Only a handful of the interactive visualization systems we have created in my lab started with a goal of supporting collaboration, but nearly all of them have ended with "fostering collaboration" being cited as one of the main benefits of the tool. To me, this points to a clear, important next step in our research, and it's my hope that the visualization community can partner with the CTS community to do this work.

ACKNOWLEDGMENT

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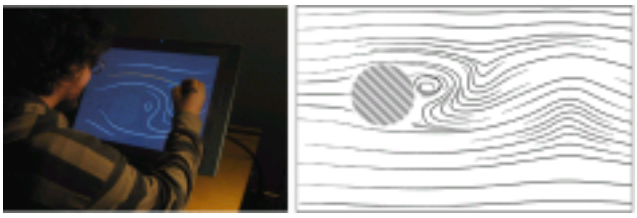

Figure 3. A 2D system for artistic design of data visualizations by "sketching on top of data".

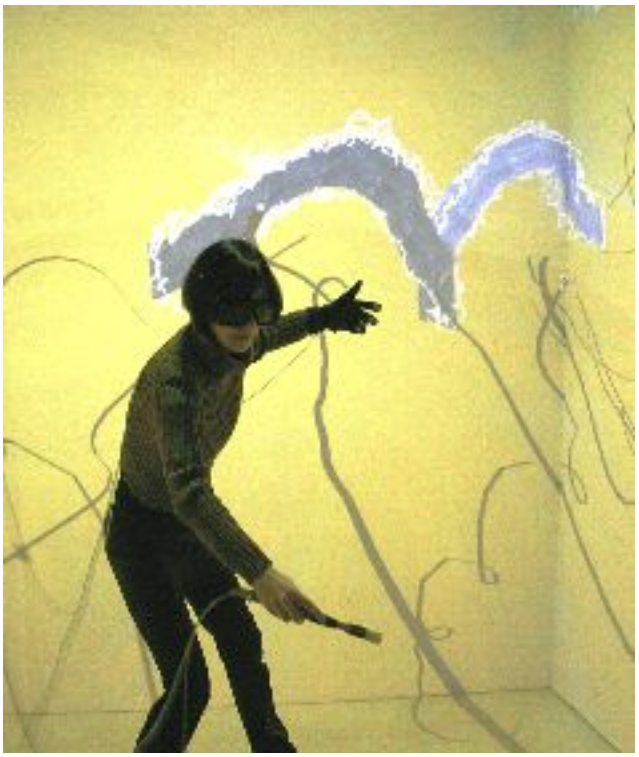

Figure 4. A 3D system that artists use to sketch ideas for immersive data visualizations in virtual reality.

BIOGRAPHY

DANIEL F. KEEFE is a McKnight Land-Grant Assistant Professor of Computer Science and Engineering at the University of Minnesota, where he directs the Interactive Visualization Lab. His recent honors include multiple career development awards, including the NSF CAREER Award (2011) and the 3M Nontenured Faculty Award (2013-14). He has published more than 50 peer-reviewed archival papers and won best won multiple best paper and panel awards at the top conferences in his field. Keefe holds a Ph.D. in Computer Science from Brown University (2007) and a B.S. in Computer Engineering summa cum laude from Tufts University (1999).