Art and Visualization: Oil and Water?

Organizer
David Laidlaw, Brown University Computer Scientist

Panelists
davidkremers, Caltech Distinguished Conceptual Artist in Biology
Victoria Interrante, University of Minnesota Computer Scientist
Felice Frankel, MIT Artist in Residence and Research Scientist
Thomas Banchoff, Brown University Geometer and Artist

INTRODUCTION

Art and visualization have progressed on parallel paths, often visiting similar points in the space of imagery. This panel session brings together artists who have scientific interests with scientists who have artistic interests. Together, we hope to stimulate excitement about searching the collective experience of centuries of artists to find concepts salient to visualization. Each of the panelists will discuss some of their work, giving concrete examples of joint art/science endeavors. We have organized our statements around the following questions:

1) How can artistic experience benefit visualization? What artistic disciplines have the most to offer?

2) What are the dangers of mixing the two disciplines?

3) How should we proceed? What are the rich research areas to explore?

POSITION STATEMENTS

David Laidlaw

For six centuries artists have developed methods for representing complex scenes in oil paintings. The work that I will show excavates concepts from oil painting and applies them to visualization. We have used multiple layers of brush strokes, motivated by Van Gogh's style, to represent multi-valued data. The resulting images simultaneously display up to eight values at each point. I'll show results of several different types of data displayed with these methods. Surprisingly, these images are richly detailed, and offer different views from different perspectives, much as paintings often do.

Creating visual representations with these methods is a delicate process of balancing the visual bandwidth used for one component of a dataset against the visual bandwidth used for another. Maintaining a relatively continuous representation in one layer without obscuring underlying information also creates tension. And choosing which parts of the data to map to quickly seen visual cues and which to map to cues with a longer latency adds a temporal dimension to the resulting images.

Of course, there are dangers in the process. The potential for misrepresentation is high because the process is subjective. The balancing act can fail, and important features can be obscured or deemphasized enough that they are missed. More subtle misrepresentations can accidentally map data to cues that have a strong unintended impact. Chernoff used iconic facial features to represent the different values in multi-valued data. Some of the features, such as the upward curve of the mouth, have a very strong emotional impact on western viewers.

There are a number of areas ripe for exploration. Only the surface of painting has been scratched. Van Gogh's brush strokes are wonderfully expressive and discrete in relation to those of many other artists. The work of other painters is likely to provide many more ideas applicable to visualization. Other artistic disciplines also hold promise. Graphic design, illustration, and sculpture all spring to mind as relevant to visualization, and some exploration has begun in these areas. Consistent "standard" visualization techniques and test cases will make comparisons possible. How to standardize something related to "art" is an interesting problem. And, finally, more visibility for this fledgling yet ancient process of mining the past will help stimulate essential interest and enthusiasm.

davidkremers

the naked human eye can distinguish intervals up to 1/100 of an inch. in order to conceptualize events beyond this limit we developed mathematics and art.

mathematics, along with the tools it helped create, took opinion out of scientific observation. what had once been metaphysics became physics. even better, the church didn't argue with these new views of the universe so long as they remained mathematics, a place invisible to the masses.

in the modern world, our combination of electronics and molecular biology is allowing humans to perceive the invisible at a resolution in sync with the limitations of the human eye. this is putting opinion back into scientific observation.

the fact that we are moving from studying inert samples to working with complex dynamic systems is forcing us to meld art and science into something new. recently i participated in experiments using optical sectioning and 3d reconstruction of stained mouse somites. the first discovery to be made was that our new visualization techniques far outstripped the standards of "artistry" at the bench. our second discovery was that the existing schematic idea of these structures doesn't match up with our organic results.

so we are testing the samples with two forms of high resolution pattern recognition. we are increasing the technical resolution afforded by recent advances in 2-photon microscopy and we are also increasing the observational resolution by taking the unique step of including an artist in the team. artists are very highly trained "eyes" in pattern recognition, and they bring an unbiased eye to biology which can question recurring patterns overlooked by the "practiced" eye of a biologist who is only looking to see what she expects to find.

art is good at qualitative questions, the chief question of art has historically been why? the question facing modern artists is how much objectivity can we afford to let in before we begin to lose the discoveries afforded art by intuition?

science is good at quantitative answers, the chief answer so far has been finding out how things work. the question facing modern science is how much intuition can we afford to let in before we begin to lose the discoveries afforded science by objectivity?

is there a new visual language out there like calculus lying in wait for newton? or are we merely performing a rehabilitation of descriptive biology with high tech pencils? we may be able to make stunning advances in math and simultaneously codify our intuitive complex actions in art to form a new hybrid math/art language. or it may be that the increasing sophistication of our art practice will afford a clearer picture of subatomic phenomena resulting in some new quantum/chemistry language.

Victoria Interrante

Is visualization a science or is it an art? Is there a science behind the art of creating an effective visual representation? How do we know how to begin designing methods for generating pictures that convey the essential information in a dataset in an accurate, efficient, and intuitively meaningful way? How do we know when we have succeeded? When we are on the right track? When we have utterly failed?

Visualization differs from art in that its ultimate goal is not to please the eye or to stir the senses but, far more mundanely, to communicate information - to portray a set of data in a pictorial form that facilitates its understanding. As such, the ultimate success of a visualization can be objectively measured in terms of the extent to which it proves useful in practice. But to take the narrow view that aesthetics don't matter is to overlook the complexity of visual understanding.

Research in perceptual psychology provides a rich source for insight into the fundamental principles underlying the creation of images that can be effectively interpreted by the human visual system. Observation of the practices of artists and illustrators provides a rich source of inspiration for the design of more complex and possibly more intuitively appealing methods for translating data into pictures.

I will present several case study examples, drawn from my research in 3D shape and flow representation, that attempt to demonstrate the potential of looking to art and illustration for insights into design of techniques for more effective visual communication. I will also discuss some of the perceptual issues that underlie the art of representing information in an accessible manner.

Visualization can be viewed as the art of creating a pictorial representation that eloquently conveys the layered complexity of the information in a complicated dataset. But it should also be viewed as the science, behind this art, of defining for others the process through which such pictures can be evolved, providing a theoretical foundation for knowing *how* to create useful images and offering insight into *why* certain representational approaches can be expected to hold more promise than others.

Felice Frankel

(The following is excerpted with permission from an original essay [1]).

The images I will show are photographs of scientific research, and I state that at the outset because their aesthetic qualities, being immediately apparent, so often seem to dominate initial reactions to them. But I, in fact, created them primarily to serve the scientific community, to record and communicate data, and to further the research. However, I have also recently become aware that the visual impact itself of the photographs I make in the lab can have significant consequences, allowing them to communicate important information about science research not only to other scientists in the lab, or in the field, but to a broader, nonscientific public, as well. So I have come to recognize and to embrace the two worlds my work inhabits, scientific and aesthetic. On the one hand, I bring to science photography my passionately curious, fresh and aesthetic eye. And on the other hand, though I am not an optical or electron microscopist, I use their tools, but I use them with a different point of view: to locate the innate beauty of the research, and to capture it with the kind of technical accuracy that can add information and generate new ways of thinking.

In my work I take the position that we who are privileged to see science's splendor, who image it, diagram it, model it, graph it, and compose its data, can turn the world around, dazzling it with what inspires and nourishes our thinking, if we refine the visual vocabulary we use to communicate our investigations and incorporate - beautifully and above all accurately - the visual component that is already there. Our goal must be to share the visual richness of our world, to make it accessible.

For me, form, shape and composition are integral to a scientific image or representation; I compose data, making it readable and comprehensible and the theorists and experimentalists with whom I work agree that visually clarified information adds another dimension to the exchange of ideas. They tend to be the investigators who are expanding their boundaries, sometimes into scientific disciplines of which they never dreamed. They are learning to use their equipment for visualizing the increasing complexity and dimensions of their work in new ways, with the same rigor in their imaging as in their scientific thinking; when what was once "good enough" is no longer good enough.

Although some of the images I take are displayed in art galleries and museums and are reproduced in books that resemble "art" books, they are not art. I do not view myself as an artist because an artist has a personal agenda and a very particular point of view, that of communicating the part of herself she wants the world to perceive. One may view the images I take as artistic, but their primary purpose is to communicate scientific information. My photographs are spare - compositions of three-dimensional forms and structures recorded on two dimensions. I frame the images in a way that emphasizes the particular point of the investigation, carefully choosing only the components essential for communicating a specific idea; more details do not necessarily add clarity. I find a readable order in the data, a hierarchy of information, guiding the viewer's eye to know where and how to look. If I digitally eliminate a dust particle or scratch, I indicate that I have done so. In sharp contrast, an artist is not necessarily committed to conveying data and may inadvertently subvert the essence of scientific investigation, its intellectual rigor, so to suggest that art and science are related may dangerously redefine each. Science may be artful, but art is not scientific.

In fact, perpetuating a false connection between science and art cannot provide a permanent basis for greater public interest in science. Science itself in its wonder and beauty can attract enough attention, even if at first it is only a glance. While an amateur, in the true sense of the word, does not deeply understand science, it is a mistake to underestimate the power of enthusiasm from outside the laboratory. For example, my enthusiasm comes with enough understanding of the subject to ask the right questions, to fashion the appropriate visual vocabulary for communication, using images as scientists use equations and formulae. But then there is the more general enthusiasm from the public, whose direct contribution to research is less obvious but whose support is just as important in the long run. That enthusiasm will only expand when science is made more accessible. Accessibility is the first step to convincing the non-scientific community no longer to accept nor be content with ignorance of physical phenomena. It will encourage the confidence to curious; and that curiosity will be reason enough to look at the remarkable world we investigate, to question it, and to attempt to understand it. But first, we must all begin to *see* it.

Thomas Banchoff

Visualizing complicated surfaces in three-dimensional space demands the ability to manipulate and illuminate objects so that their essential features and their interrelationships become more and more apparent. Much more challenging is the process of trying to visualize surfaces in four-dimensional space, requiring even more views and more explorations of shapes from many different perspectives. Communicating the insights gained from visualization activities involves decisions about the best ways of presenting multiple views or animations, especially in circumstances where an object is undergoing deformations.

There is an art to making these decisions, and it is no accident that the choices made by geometers correspond in striking ways with the selections made by professional artists considering the same collections of images.

"Surfaces Beyond the Third Dimension" is the title of a one-person show at the Providence Art Club that first took place in March of 1996 in Providence RI. That exhibit lives on as a virtual art gallery on the Internet [2], and we can learn new ways of interacting with such geometric art by considering the different pieces and their relation to one another.

What have we lost when we no longer have the chance to walk through the actual physical space of the gallery? What have we gained, by allowing each viewer to interact with the various pieces at his or her own level of appreciation of the color, rendering, and shape of the displayed objects, as well as the mathematical background and context that causes these pieces to be chosen for investigation?

Does such a multi-layered gallery enhance the artistic experience of viewers, or can the amount of subsidiary information get in the way of their appreciation? Can the same objects double as art works and illustrations of mathematical relationships? Does the answer to this question depend in essential ways on the kinds of computer renderings or the kinds of mathematical objects under investigation? What lies in the future, as computer graphics opens up new areas for geometric exploration, and new views of geometric objects provide challenges both for communication and for aesthetics?

BIOGRAPHIES

David Laidlaw applies computer graphics and computer science to problems in other scientific disciplines. He is an Assistant Professor of Computer Science at Brown University. He received his Sc.B. and Sc.M. from Brown, where he worked with mathematicians to understand 2- and 3-manifolds. He received his Ph.D. in Computer Science from Caltech in 1995. His thesis presented new methods for extracting geometric models from medical imaging data of biological specimens. He is currently investigating computational methods with applications in developmental neurobiology, diagnostic medical imaging, remote sensing, and fluid mechanics. Research interests include tissue classification, visual representation of data, modeling of imaging data, optimization of data acquisition, geometry, numerical methods, and statistics.

davidkremers is an artist inspired by the confluence of art and science, and has recently been appointed the Caltech Distinguished Conceptual Artist in Biology. He grew the first paintings from genetically engineered bacteria and his work combining living organisms and digital media has evolved into biospace station concepts and visual information systems for biotechnology research. His art has generated numerous gallery and museum exhibitions in the United States, Germany, Belgium, Denmark, and Austria. His artwork may be viewed in real time at public collections of the Denver Art Museum, the San Francisco Museum of Modern Art, the Eli Broad Family Foundation, and the Panza Collection.

Felice Frankel is artist-in-residence and research scientist at MIT. She has received grants from the Guggenheim Foundation, the National Endowment for the Arts, the Graham Foundation, the Camille and Henry Dreyfus Foundation and has recently received major funding from the National Science Foundation for her work in scientific imaging and visual expression. Her work has appeared on the covers of Nature, Science, and many other journals. Frankel is coauthor of "On the Surface of Things, Images of the Extraordinary in Science" (Chronicle Books, 1997).

Victoria Interrante is an assistant professor of computer science at the University of Minnesota. She received her PhD in 1996 from the University of North Carolina at Chapel Hill, where her dissertation research focused on the design of perceptually inspired artistic techniques for improving the comprehensibility of layered transparent surfaces in radiation therapy treatment planning data. Before coming to the U of M, she spent two years as a staff scientist at ICASE, a center of research in applied mathematics, numerical analysis and computer science operated by the Universities Space Research Association at the NASA Langley Research Center. Her broad research interests are in visualization, visual perception, computer graphics, image processing and human-computer interaction. She is currently working on applying insights from visual perception, art and illustration to the design of methods for more effectively portraying surface shape and depth in computer-generated images.

Thomas Banchoff is a geometer who has been teaching mathematics at Brown for thirty years, and collaborating during all that time with computer scientists and students to produce visualizations of surfaces in four-dimensional space. He studied mathematics and English at the University of Notre Dame and earned his Ph.D. at Berkeley in 1964. He taught two years at Harvard University and one at the University of Amsterdam before coming to Brown. With computer scientist Charles Strauss, he produced the award-winning film ``The Hypercube: Projections and Slicing" in 1978, and numerous other films and videotapes, as well as sixty articles and books on geometric topics, including the Scientific American Volume "Beyond the Third Dimension." He received the national award for outstanding teaching from the Mathematical Association of America in 1996 and he is now president-elect of that organization. In 1997, the Carnegie Foundation named him Rhode Island Professor of the Year.

REFERENCES

[1] Felice Frankel, Envisioning Science - A Personal Perspective, *Science,* 280(5370) (1998).

[2] "Surfaces Beyond the Third Dimension," Web Page, `http://www.math.brown.edu/~banchoff/art/PAC-9603/welcome.html`