Realism, Expressionism, and Abstraction: Applying Art Techniques to Visualization

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

Panelists:
David Laidlaw, Brown University
Victoria Interrante, University of Minnesota
Christopher Healey, North Carolina State University
David Duke, University of Bath

Motivation:

The visualization and computer graphics communities have recently become fascinated with the application of artistic techniques to three dimensional computer generated imagery. These are sometimes called non-photo realistic rendering techniques. This raises the key issue of when is it appropriate to apply realism, expressionism, and abstraction points of views to scientific and information visualization? What additional insights are gained from overlapping these approaches? The eye, the emotions, and the intellect all share in the process of creating and exploring visual art forms, including computer generated imagery. This panel examines a few non-photo realistic rendering approaches and highlights the impact these methods have on gaining insight from the resulting scientific and information visualizations.

Position Statements:

Theresa-Marie Rhyne:

In applying art techniques to visualization, it is my belief that we are using the shock of the old and classical to gain new insights. Exploring a more traditional art medium, a painting is a layer of pigments applied to a surface. Its arrangement of shades and colors projects the personality of the artist who painted it. Paintings are partial statements of the philosophy of the age that produced it. However, it can have meaning beyond anything concerned with the one person who painted it or the era in which it was created. A computer generated image, too, is a reflection of the technological environment in which it was produced and can transcend its creator.

In discussing realism, expressionism and abstraction, we are dealing with the artist's point of view of subject matter. Realists reflect the look of the world around them. A realist, painting a tree, provides a fairly accurate reproduction of the way the tree looks, leaving to the viewer any emotional or intellectual reaction. Photo-realism techniques are fundamental to the field of computer graphics. The expressionist, in contrast, is less interested in reflecting the world than in revealing responses to it. Taking the same tree, expressionists distort its form and color to express emotions in a personal and subjective way. Non-photo realistic computer generated techniques explore these distortions. Interested in neither reproducing the look of things, like the realist, nor in being specific about emotional reactions, like the expressionist, the abstractionist is interested in the world as a complex of ideas. If interested in trees, the abstractionist would ask what the idea of a tree might be and proceed to visually depict a pattern revealing that idea. Some mathematical relationships and the computer imagery associated with them are abstractions.

It is my opinion that the application of non-photo realistic techniques to visualization is part of the maturation of computer graphics as an art medium. Traditional art approaches, like painting, progressed through phases of realism, expressionism and abstraction. Visualization seems to have skipped over expressionism and is now rediscovering it!

David Laidlaw:

Concepts from oil painting have the potential to help us more effectively show more information in a given visualization. I'd like to explore, with the audience and the other panelists, some of the reasons for this and some experiments in applying these ideas to visualization.

Many oil paintings appear (to me, at least) much more information rich than most computer-generated visualizations. Partly, this is because oil paintings are typically much higher resolution. I think that a second reason is that paintings are viewed from many perspectives, and so they are often created to work differently from those different perspectives. Third, the paintings that I'll show as examples were clearly very carefully designed not only to work from different perspectives, but to have a temporal nature, guiding the viewing through the process of interpreting the painting.

0-7803-7200-x/01/$10.00©2001 IEEE.

To illustrate these points, and perhaps some ways to take advantage of them for scientific visualization, I will show Impressionist paintings, visualizations created using similar concepts, and some more experimental images. At SIGGRAPH 2001, I am one of the instructors for a course where the attendees will use multiple traditional art media (paint, markers, pastels, etc.) to experiment with visualization of multi-valued scientific data. I hope to draw some lessons from the coursework, and will share them in this panel.

Victoria Interrante:

In my view, the essence of visualization research is the science and art of designing, implementing and evaluating methods for effectively communicating information through images. Although the primary focus of our community, up until this point, has been on solving the difficult implementation problems inherent first in enabling and then expediting the translation of data into images, increasing attention as of late has been turning toward the equally important problems of principled design and rigorous evaluation. How do we determine how best to portray a large, complicated set of data so that the essential information it contains can be easily and intuitively understood? How do we measure the success of our efforts? Where can we look to find insight into the science behind the art of effective visual representation?

In this panel, I will discuss issues of realism, expressionism and abstraction in the context of my ongoing work on several related visualization projects: using properties of natural textures to convey information about multiple superimposed scalar fields over 2D maps, using oriented textures to enhance the appreciation of 3D surface shape, and investigating the efficacy of using of abstract representations of selected scene elements in immersive virtual environments as generic stand-ins for specific elements whose detailed characteristics are unknown or unimportant - combining realistic and expressive representational styles in a way that our visual system is willing to accept.

Christopher Healey:

Artistic works have the ability to evoke powerful emotional responses, to convey complex ideas, and to inspire viewers with their beauty. New research conducted in my laboratory is searching for ways to unlock some of this power during scientific visualization. In particular, we are interested in using nonphotorealistic techniques from computer graphics to visualize large, complex, multidimensional collections of data. Our goal is a painterly image that is aesthetically beautiful on the one hand, but that still allows viewers to "see" values, trends, and relationships in their underlying data. Our work-to-date on visualizing multidimensional data has focused in large part on ways to harness the low-level human visual system. The appropriate use of perceptual cues can significantly enhance a viewer's ability to explore, analyze, validate, and discover. An investigation of art history and artistic techniques suggests that the painterly styles used in the Impressionist movement correspond closely to the visual primitives we apply during visualization. In some sense this is not surprising. Artistic masters understood intuitively which properties of a painting would capture a viewer's gaze, and their styles naturally focused on harnessing these features.

I believe the relationship between fundamental visual features and brush stroke styles can be used to build painterly visualizations that are both expressive and aesthetically powerful. Simulated brush strokes that vary in properties like color, path, energy, and placement can be used to represent individual data elements. If perceptual rules from visualization are consulted to guide the application of these brush stroke properties, we can guarantee a perceptually salient image. The result is a nonphotorealistic display that is both visually engaging and effective in its ability to support rapid and accurate exploration of large amounts of data. In my opinion, this marriage of art and perception will have far-reaching effects for the scientific visualization, psychophysics, and artistic communities.

David Duke:

While visualization has developed a powerful palette of representations -- isosurfaces, streamlines, and glyphs for example, the "virtual camera" model that underpins much of computer graphics has sufficed to apply these representations to the display. Why might we want to augment the clarity of cameras with the "brush strokes" of artistic techniques? My answer is connected with the challenge of scale. Independent of how computationally efficient we make visualization algorithms there is a dual problem: how cognitively effective are the images that result?

The problem of overloading the user with detail is being addressed through simplification techniques. A nice example is the creation of topological abstractions (vortices, sources, sinks etc) in flow visualization. This problem is challenging in itself -- in what sense for example can you "approximate" a discrete structure, for example, a graph? I will refer to one approach that suppresses detail in quasi-hierarchical structures by replacing parts of the representation with a "skeleton", and using visual cues based on metric information to highlight the distribution of structure.

However, once we have found suitable abstractions, how should they be rendered? My view is that this is where artistic techniques become almost essential. In the introduction to this panel, Theresa-Marie Rhyne states that the eyes, the emotions and the intellect all have a role in interpreting visual art forms. In the case of abstractions, artistic techniques offer the following benefits:

1. To the eyes, they can be used to make a visual distinction between detail and overview. The detailed, low-level structure of a representation may indeed be rendered most effectively using realistic lighting and shading models, but by using artistic techniques in rendering, it becomes possible to highlight WHERE abstraction is present.

2. To the emotions, artistic images have qualities that afford interpretation and exploration better than "hard" images. This has been demonstrated in areas such as CAD and architecture through work on sketch rendering by Schumann et al [1], who looked at the use of sketch-rendering in architectural design. Sketches have an affective quality that encourages dialogue between client and architect. A sketch gives an impression of incompleteness or openness to exploration that is missing from realistic images. Where there is abstraction or overview in visualization, artistic techniques may be used to encourage the viewer to explore that part of the structure further.

3. For the intellect, as the work of other members of this panel has already shown, artistic techniques can be used to convey information in a way that is difficult with standard methods. What might we want to say about levels of abstraction? One answer is what kind of abstraction is this, i.e. what has been hidden? What clues can we give about what would be revealed if the user "drilled down" through the abstraction to reveal the dataset in greater detail? And can we use properties of the representation to give clues about the level of error or approximation introduced by the abstraction?

Of the different schools of artistic expression, of most interest to me are techniques used in paintings from South-East Asia, which had an impact on the European Impressionist and Post-impressionist movements. Compared to paintings of the "realist" schools, certain detail is omitted, hinted at, and left for the viewer to complete. By developing a "minimalist" style of graphics, might we be in a better position to manage the complexities of our data? Unless we do find such a way of dealing with visual complexity, the human visual and cognitive systems may well become the real bottleneck in the visualization pipeline.

[1] J. Schumann, T. Strothotte, A. Raab, and S. Laser, "Assessing the effect of non-photorealistic rendered images in computer-aided design", Proc. CHI'96, Human Factors in Computer Systems, pp. 35-41, ACM Press, 1996.

Biographical Sketches for Panelists:

Theresa-Marie Rhyne: (rhyne@siggraph.org)

Theresa-Marie Rhyne is currently a multimedia visualization expert with the Learning Technology Service at North Carolina State University. In the early part of 2001, she was an independent consultant in 3d computer graphics and visualization. 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 US EPA Scientific Visualization Center. She was the founding visualization expert at the Center. Currently, she serves on the editorial board of IEEE Computer Graphics and Applications (CG&A) and is co-editor of its Visualization Viewpoints Column. She is also a practicing fine artist in the mediums of collage and computer graphics and exhibits her work internationally.

David 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 multivalued multidimensional imaging data, modeling of shape and behavior, 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.

Victora Interrante: (interran@cs.umn.edu)

Victoria Interrante is a McKnight Land-Grant Professor in the Department of Computer Science and Engineering at the University of Minnesota. She received her PhD in 1996 from the University of North Carolina at Chapel Hill, where she studied under the joint direction of Dr. Henry Fuchs and Dr. Stephen Pizer. From 1996-1998 she worked as a staff scientist at ICASE, a non-profit research center operated by the Universities Space Research Association at NASA Langley. Her research focuses on the application of insights from perceptual psychophysics, art, and illustration to the design of more effective techniques for visualizing data. Some of her current projects include: the study of texture's effect on shape perception and texture synthesis for shape representation, the study of texture perception and classification for texture synthesis in multivariate data visualization and uncertainty representation, the segmentation and tracking of vortical structures in turbulent boundary layer data, and feature identification for gaze direction determination from uncalibrated photographs. Her work involves collaborations with researchers from a variety of departments at the University of Minnesota, including Electrical Engineering, Aerospace Engineering, Mechanical Engineering, Ophthalmology, and Child Development. In 1999, she received a Presidential Early Career Award for Scientists and Engineers.

Christopher Healey (healey@csc.ncsu.edu)

Christopher G. Healey is an Assistant Professor of Computer Science at North Carolina State University. He received a BMath at the University of Waterloo, Canada in 1990 and a MSc and PhD at the University of British Columbia, Canada in 1996. During his PhD, he was supervised by Dr. Kellogg S. Booth (Department of Computer Science) and Dr. James T. Enns (Department of Psychology). Prior to starting at North Carolina, Healey completed a two year postdoctoral fellowship in computer graphics with Dr. Carlo Sequin at the University of California, Berkeley. His research focuses on methods for visualizing large, multidimensional datasets. Active research projects include techniques to harness low-level human vision for information display, intelligent methods for automating the construction of visualization designs, data compression and data management, and simulating artistic techniques for multidimensional visualization. Healey has taught undergraduate and graduate courses in computer graphics and visualization, and has organized and lectured in courses at SIGGRAPH 98, 99, and 2001.

David Duke: (D.Duke@bath.ac.uk)

David Duke is a lecturer at the University of Bath. He currently holds an Advanced Research Fellowship from the UK Engineering and Physical Sciences Research Council, within which he is working on methods and principles for large-scale visualization. He studied Computer Science at the University of Queensland in Australia, receiving his BSc there, and then his PhD in 1992 for work on object-oriented specification. That year he moved to the UK to join the University of York, where he worked for 3 years on a multi-disciplinary HCI project, Amodeus-2. His work in visualization grew out of a collaboration with colleagues at CWI Amsterdam on graph visualization. This has since broadened to include non-photorealistic rendering, evolving out of a shared interest in the techniques used in Japanese and Chinese painting. An active member of the Eurographics Association, he is currently co-editor of its journal, "Computer Graphics Forum". See www.bath.ac.uk/~masdad/ for further details.