

Point of View

THE EYE RESEARCH INSTITUTE UNIVERSITY OF WISCONSIN-MADISON

Visualization: Seeing to Understand

Vision is our primary mode of information gathering. So much of what we know is acquired through vision, that we commonly use the phrase “I see” to mean that we understand. Thinking in pictures, we use the expression “mind’s eye” to reference the imagery we experience within our brains as we remember and reconstruct faces or landscapes, or as we literally envisage new scenes, inventions, and connections. Our ability to visualize—an integral part of human consciousness—supports learning and creativity.

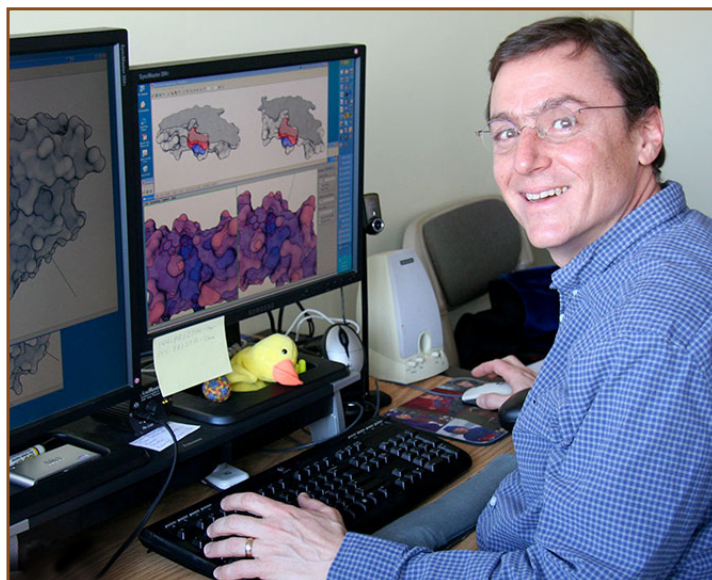
While our visual thinking process has been well enhanced by maps, illustrations, diagrams, graphs, web pages and information graphics, these tools alone are insufficient to address the growing volume and complexity of information being produced in every domain of science, engineering, and human activity. Michael Gleicher, professor in the department of Computer Sciences and member of the UW Eye Research Institute, is exploring new avenues to develop visualization tools that can facilitate comprehension, improve data accessibility, clarify relationships, and advance comparisons. In a computer science context, “visualization,” the process of trying to understand or explain data or concepts through pictures, is grounded in what is possible computationally—using a toolbox of mathematics, engineering, and computer science applications.

Visualization is based on knowledge of perception and human visual processing. For Gleicher, learning more

about perception is essential to building better visualization tools. With students and colleagues, he raises this question: “How can we use our understanding of human perception and artistic traditions to improve our tools for communicating and data understanding?” Perceptual researchers have delineated neural responses to light, color, object orientation, proportion, pattern, depth and movement, as well as computational approaches explaining how neural responses occur. They are linked to centuries of artists who have recognized and utilized knowledge of these same visual cues. Both art and science perspectives inform visualization development.

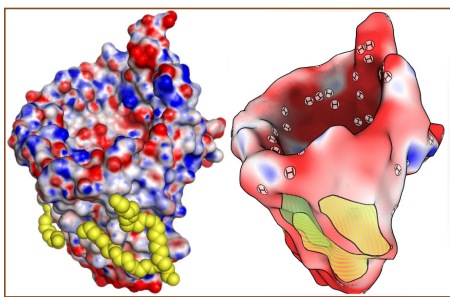
“Neuroscientists and cognitive psychologists who conduct rigorous studies of human perception are discovering facts about what we do and do not see and notice, and why; they can help us understand the existing limits of the visual and perceptual mechanisms that dictate the propensities and capabilities of human perception,” notes Gleicher.

For example, sometimes it is valuable to simplify a representation so that unnecessary details do not distract from understanding the big picture. While this



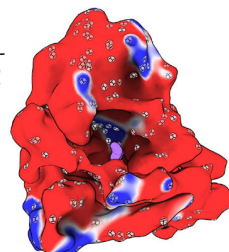
Michael Gleicher, PhD, compares multiple views of protein surfaces.

requires contextual knowledge of which details are significant and which can be removed, this approach has proved to be effective in Gleicher’s work with structural biologists seeking to understand the relationship between protein structure (geometry and physical properties) and function. Gleicher developed a visualization tool to help discern how shape influences what a molecule does and how it leads to biological function.



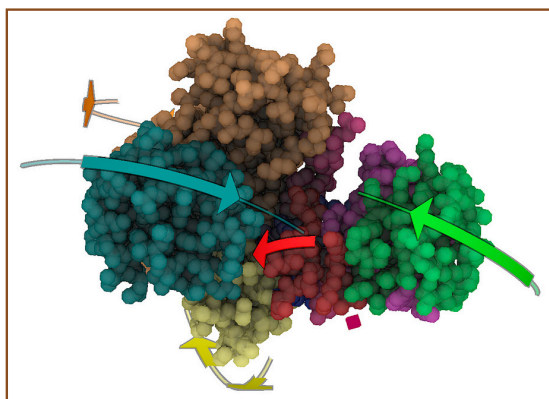
A porine molecule depicted using a Pymol visualization tool shows surface detail that seems to hide pertinent information (left), but is transformed by using abstraction techniques that smooth and simplify surface coloring and geometry (right). (M. Gleicher/G. Phillips image)

This abstracted representation of an enzyme involved in penicillin synthesis helps users see its overall structure and the bound acid molecule in purple at its center. (M. Gleicher/G. Phillips image)

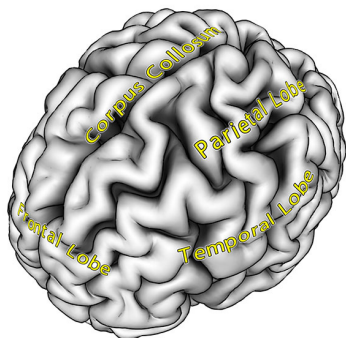


Termed “molecular surface abstraction,” the application smoothes over detail and stylizes the molecular surface, allowing for more rapid assessment of molecular form. Comments Gleicher, “Our goal is to present a picture so that you are most likely to see the shape. From a perception aspect, the eye perceiving a 3D form looks for anything it can use—shape, lines, color cues, shading. So by applying artistic principles (color value, contrast, pattern) to representing the form and function of a porin molecule, we reveal a funnel shape that you otherwise would not see.” This channel through the center of the molecule is an important feature of this type of protein; making it visible to the biologists who study it allows for a clearer understanding of the larger role of this protein, which controls the flow of sugars, ions, amino acids and other molecules.

Efforts to understand protein function have led to developing molecular motion abstraction tools featuring interactive visualization and animation for modeling molecular flexibility and movement. Yet



Groups of atoms that move together within this protein molecule are shown using the same color; arrows indicate motion potential for these groups of atoms in relation to one another. Relative length of the solid arrows shows magnitude of motion. (M. Gleicher/G. Phillips image)



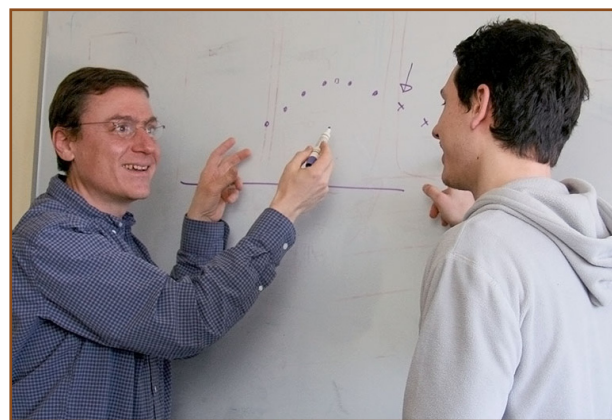
Text scaffolding is a technique that allows words to be applied directly to an image, so they appear to “flow” over the surface without sticking in cracks.

using static display remains most useful for making comparisons among molecules. Incorporating ideas learned from how artists present motion, Gleicher and team employ still pictures that simplify a molecule’s motion by dividing it into a smaller number of parts and drawing arrows that depict the motion of each piece.

Another outgrowth of the molecular abstraction project is a method of information labeling termed “text scaffolding,” a mapping technique allowing words and symbols to be applied to an image with complex, curved surfaces. “Labels positioned directly on object surfaces provide shape cues, place information in context, and do not obscure other parts of objects,” states Gleicher.

These molecular surface abstraction, motion abstraction, and surface cartography tools are examples of stepping stones along a pathway toward developing common methods and principles for a science and practice of comparative visualization. Advances in imaging, sensing, communication and computation are generating massive collections of complicated data which require comparison for understanding. Gleicher brings excitement and determination to an ambitious and challenging goal. He explains, “While visualization is a mature field where theoretical progress has led to practical and collective tools, comparative visualization has been less well studied. In some cases we have rules of thumb, and studies have probed the potential and limits of specific techniques. But much remains to be done to address the problem of how to design visual tools for comparing complicated things.”

By studying a range of visual applications in diverse domains like genetics, educational psychology, neuroscience, engineering and biochemistry, Gleicher hopes to find general principles and common technologies that can be applied in developing tools and systems that will support visual comparisons of vast



With graduate student Yoram Griguer, Gleicher discusses a problem-solving method used in real-time data interpretation.

amounts of data. One of his new projects focuses on seeking effective visual representations of the extensive DNA data scientists need to compare genome sequences.

Given that there are limits to our perceptual and cognitive processing abilities, how can we use visualization to help make sense of huge data sets? How can we build comparison tools that will advance understanding of all that we cannot easily see and comprehend? The work of researchers in many disciplines is enhanced as computer scientists create visualization tools addressing their needs; and the very process of developing these tools allows computer scientists to learn more about the general principles underlying them. Encouraged by ERI interdisciplinary support, Gleicher is confident that answers will evolve from collaborative efforts across campus.



The UW Eye Research Institute

445 Henry Mall #307

Madison, WI 53706

608/265-0690

email: info@vision.wisc.edu

website: vision.wisc.edu

Daniel M. Albert, MD, MS

Retina Research Foundation

Emmett A. Humble Distinguished Director

Arthur S. Polans, PhD

Associate Director

Tracy D. Perkins, MPH

Administrative Director/Editor