Researchers 'visualize' their work with computers

Ye Zhang | | Date: 12/3/2003

But to Cai and his 3-D hydro group, these disks are a form of "scientific visualization" that allows scientists to quickly see the inherent relations among large amounts of data. By identifying trends and structures and recognizing shapes and patterns, such visualizations help scientists more effectively "see" what it is they are doing.

Cai's research group, led by IU astronomy professor Richard Durisen, is involved in the study of the form of planets. In their study, they use neither telescopes nor pictures taken by astrograph to watch remote stars and record their orbits. Instead, this group largely depends on what they call "supercomputer animations." They employ a designer, John Rosheck, who creates animations to mimic the form of the earth based on simulations done by other group members.

"The mathematical equations that describe real physical systems are often too complicated to solve exactly with pencil and paper," Durisen said. "So scientists write the equations in forms that digital computers can solve."

Durisen said the computerized visualizations do not provide precise answers. Instead, they allow some simplified mimicry of reality that provides an indication of how the real systems will in fact behave. Thus, scientists say they are "simulating" the system.

"What I do is produce animations from the data created by the simulation," Rosheck said.

To produce a 30-second movie requires two weeks and uses 1,000 frames.

"I produce graphical images of the density at various time points in the simulation, then put them all together to make an animation," he said. "This allows others in the group to see the structure and effects that aren't readily apparent in the statistical data."

The software used to create scientific visualization is similar to what is used by the entertainment industry to make cartoon animations. The difference is that what is animated by these scientists is data from a computation based on scientific principles. In each animation, the observer is looking down from above at swirling disks of gas. The color scale indicates the density of the gas, with reds being 100 times denser than greens, greens being 100 times denser than the dark blues and blacks being essentially empty space. For the group to understand calculations generated from the data, it helps to use "visualization" techniques in the form of "movies" that show how the gas disks behave.

Visualization of scientific phenomena is not only useful for scientists' own research. It has teaching and educational applications, too. "Information visualization" permits people without a science background to effectively "see" science through the visualization process. Information visualization is what Katy Börner and Margaret Dolinsky have been busy creating.

Börner, an assistant professor of information science and a member of the core faculty in cognitive science, said scientific visualization is based on data sets that can actually fall into an X-Y axis. Information visualization typically deals with non-spatial information -- such as log files reporting access of Web pages or citation data -- that needs to be mapped into a physical space. Information visualization is concerned with easing access to and understanding of information. If done successfully, it can shift users' mental load from slow reading to fast visual pattern recognition, enabling the user to observe, interact with, and comprehend very large amounts of data.

Börner and Dolinsky both agree the visual representation of information requires a deep understanding of human perceptual and cognitive capabilities, computer graphics, interface and interaction design, as well as creativity and artistic skills.

Supported by the Institute of Public Health in her home country, Germany, Börner did a project recreating the sound landscape. Normally, one does not see sound, but this particular visualization made the sound level visible by using a third dimension -- the decibel level.

"If you want to see what are the areas where the decibel levels are really high, of course they are the streets that stick out there," Börner said.

The simulation revealed the way in which a new manufacturing plant would affect the noise level in a particular residential area. The 3-D visualization helped German government officials to enact noise protection regulations for new streets in industrial areas.

Dolinsky, who used to work with Börner, once did a similar 3-D project on the human ear when she worked in Chicago. In the visualization she created, audiences were able to walk into the canal of an ear, see the bones and hear voice sounds inside the ear.

In this work, Dolinsky has come to realize that the use of art in visualizing science also creates a certain beauty .

"Scientific visualization may require parameters and clear information," she said. "Artists also need to be creative dealing with colors and design structure to make users understand, so the process in science-related visualization is not much different from personal creation of art. I believe that scientists and artists working together will provide new knowledge bases, expand creative thinking and design dynamic forms of pedagogy."

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