No, it wasn't the heat and dryness of New Mexico that led researchers at Sandia National Laboratories to generate the stack of spherical ice cubes hovering over Lake Tahoe! Researcher Pete Watterberg produced the cool image featured on the cover as part of the research on scene synthesis done at the Department of Energy facility in Albuquerque.

A considerable amount of the computing done at Sandia involves large-scale modeling using Cray machines. But the volume of output is not very useful if it requires a redwood tree's worth of paper to print it. Powerful graphics techniques are absolutely mandatory.

The Applied Computer Graphics division had already developed several commercial and private libraries and a virtual interface to more than 40 output devices. Yet even better tools were needed to visualize complicated surfaces and to display such 3D objects as molecules, in motion. Graphics developers Watterberg (now at the DOE's Savannah River facility at Aiken, South Carolina) and John Mareda began to explore scene synthesis as one of the needed graphics tools.
Scene synthesis development

Figures 1, 2, and 3 demonstrate the evolution of the scene synthesis work over the last three years. Initially, a sphere was the only geometric object manipulated, but a lot can be done with a lowly sphere, as Figure 1 shows. Different surface textures were generated using modifications to the normal direction, a 2D image was mapped onto the surface using a modification of this texture-mapping technique, and both reflection and refraction were incorporated into the ray-tracing technique.

Next the ability to manipulate other geometric shapes, including cones, ellipsoids, and super ellipsoids, was added to the software. This addition was sufficient to generate Figure 2. Currently, synthesized scenes may include two arbitrary surfaces, including fractal surfaces, as is demonstrated by the terrain and clouds in Figure 3. The pilots in the glass flying saucer are Watterberg and Mareda.

The image on the cover uses the same combination of techniques. The mountains are a fractal surface viewed in perspective as 2D noise, and appropriately colored. The same set of data was plotted as contours, and then colored with blues and whites to produce the sky and clouds. The significant problem conquered by Watterberg was to find a straightforward approach to do the mountains, which can be prohibitively expensive in terms of computation time. He found a way to generate the mountains in one day's worth of computer time. For example, instead of using a triangular mesh when breaking the surface into a quadtree, Watterberg used a square mesh.

Efficiency is a major consideration in applying ray-tracing techniques to fractal surfaces. Watterberg used a technique that bounds the fractal surface tightly with an enclosing sphere whose intersection by a ray can be quickly determined. Fractal surfaces are now being studied for the realistic representation of bodies of water. Very realistic still pictures have been generated, and work is progressing on animated wave motion.

Recent additions to the software include a wire-frame capability, so a scene can be rendered quickly for debugging, and the implementation of a hierarchical data structure, so a group of objects can be scaled, rotated, and translated as though they were a single object. This will make it much easier to do animation using the scene software.

Practical applications

The scene synthesis software has been put to practical use by Sandia scientists in several ways. Figure 4 is a still from a movie produced by researcher Mike Coltrin of the Laser and Atomic Physics Division as part of a study of the dynamics of dissociation products of silane as a function of applied energy. The principal interest was in the concerted motion of the hydrogen atoms. The silicon atom (center) was made semitransparent to facilitate depth discrimination by allowing the colored hydrogen atoms to show through as

Figure 4. Scene from a movie produced by Mike Coltrin showing the dynamics of dissociation products of a silane molecule as a function of applied energy. Scene synthesis techniques provided depth discrimination that is otherwise difficult to achieve. The silicon atom in the center was made semitransparent to enhance understanding by letting the hydrogen atoms show through as they pass behind it. This movie revealed concerted motion of the hydrogen that was not previously known and would have been difficult to detect without the use of the movie.
they pass behind. The star field in the background is strictly for aesthetics. These movies have revealed phenomenological details of the concerted motion of hydrogen atoms that have not been seen before, and which would have been difficult to detect otherwise.

Watterberg and Mareda made the scene synthesis software even more useful by incorporating it into DISSPLA, ISSCO's high-level graphics package. Users can now consider the scene synthesis software as an enhancement to the DISSPLA package they already know and use. Figures 5 and 6 demonstrate this enhancement. Figure 5 is a wireframe rendering of a surface, and Figure 6 was created using the scene synthesis software and incorporating the result into DISSPLA. The shading provides a better understanding of a complicated surface.

Figure 7 shows the next step in this development. Here, a surface is surrounded by mirrors to enhance the viewing. Recent research has also generated stereo pairs of synthesized scenes. Finally, the scene software has been transported to a 10-CPU Elxi 6400 as part of another research effort on parallel processing (multi-tasking) for graphics production.

The work of Watterberg and Mareda has significantly advanced the capability of the graphics tools available to Sandia computer users. At the same time, it has been such fun that they devoted huge amounts of their own time to the work, snatching idle computer cycles whenever they could. One can't ask for much more from any research effort.

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