Interactive computer graphics

Outstanding developments this year included a collaborative visualization software toolkit for large-scale simulations, graphics hardware and software advances in high-resolution rendering of large-scale simulations, and availability of 3D graphics hardware on laptop PCs.

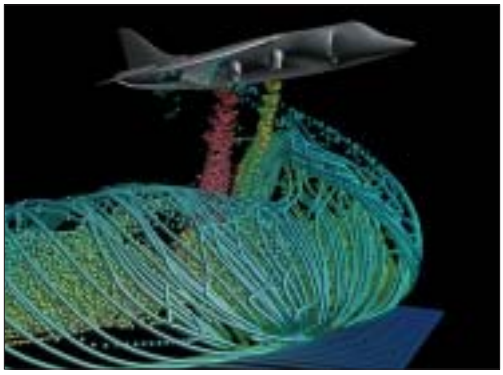
A software toolkit for visualization of large-scale computational fluid dynamics (CFD) data sets has been developed at NASA-Ames. The toolkit, named Gel, uses new algorithms that enable the visualization of large data sets on personal workstations. These algorithms are called "out-of-core" visualization techniques, because they leave most of the data on disk instead of loading all of it into main memory ("core"). Since many visualizations examine only a small fraction of the data set at any one time, the currently needed amount of data is often small enough to fit into a workstation's main memory. Reducing the volume of data required is important, because it allows the visualization to be computed at the workstation's maximum performance level.

The Gel toolkit is used at NASA-Ames to visualize CFD data sets containing hundreds of gigabytes of information. Gel has been extended to provide collaborative visualization between remote sites. A demonstration of this capability between distant locations (L'Aguila, Italy, and Moffett Field, California) illustrated that dynamic 3D scenes of complex fluid dynamics can be interactively manipulated and synchronously viewed using relatively low Internet bandwidths (less than 5 KBps).

Under the Dept. of Energy Accelerated Strategic Computing Initiative (ASCI), time-dependent simulations are being performed that use computational grids with over 100 million nodes and thousands of time steps. Terabytes of data are generated, and their postprocessing can overwhelm traditional high-end visualization tools. In order to understand the detailed physics, a range of new hardware and software technologies are being developed so that scalability in rendering speed and screen size can be obtained cost-effectively. Researchers need to render scenes in high resolution and with reasonable frame rates. High-resolution images allow an engineer to see multiple scales in a single image or scene without "zooming" in and out.

Research at Stanford University under the ASCI program has resulted in the development of two key elements of these proposed new ASCI visualization environments. One is scalable rendering clusters made up of commodity microprocessors and graphics cards; the other is a software library called wireGL that allows OpenGL programs to render their output in higher resolution tiled displays without changes to the source code. This combination allows existing visualization programs to achieve scalability in screen pixel size. In order to obtain scalability in scene size, it is necessary to parallelize the rendering application so that multiple streams of OpenGL commands can be issued simultaneously to the multiple graphics cards in the cluster.

One of the first applications to use Stanford's wireGL is MIT's pV3 visualization system. MIT's pV3 software has been extended to use wireGL and has been parallelized to overcome the scene size scalability bottleneck. The result is a scalable visualization framework that can be used interactively with very large data sets. Using multiple processors, this combination of customized software and commodity hardware achieves rendering rates that surpass those of expensive high-end visualization supercomputers at a fraction of their cost.



Visualization of the ground vortex and jet exhaust of the Harrier fighter jet was created using NASA's Gel. The streak lines depicted in these figures are colored by temperature (blue depicts cool, red is hot).

Finally, this year saw the continued migration of graphics hardware from high-end to low-end systems. High-performance 3D graphics cards and drivers are now available on laptop PCs that use Windows 2000, NT, or Linux operating systems. Interactive 3D applications that once required a workstation or PC can now be operated on a laptop PC. This enhances communication and collaboration among engineers.

by **David E. Edwards**