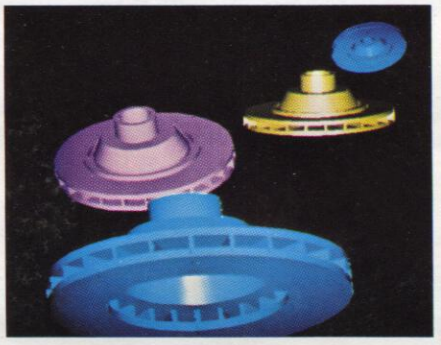
Solid modeling eliminates pixel-by-pixel generation

Lexidata cuts solid model display time from minutes to seconds

Joseph P. Lerro, Jr., Senior Editor

In development since the late 1960s, solid modeling has finally become commercially important. By the end of this decade, solid modeling will be used extensively in mechanical design and manufacture, 3-D medical and geophysical data interpretation, animation, architecture, technical illustration, building and plant construction, NC verification, and molecular modeling.

This growth in solid modeling will be spurred by the rapidly advancing technology of raster display systems and the emergence of super minicomputers which will cost-effectively meet the computational and display requirements.



Disk brake rotor exemplifies Lexidata SOLIDVIEW solid-modeling technique.

Lexidata technology

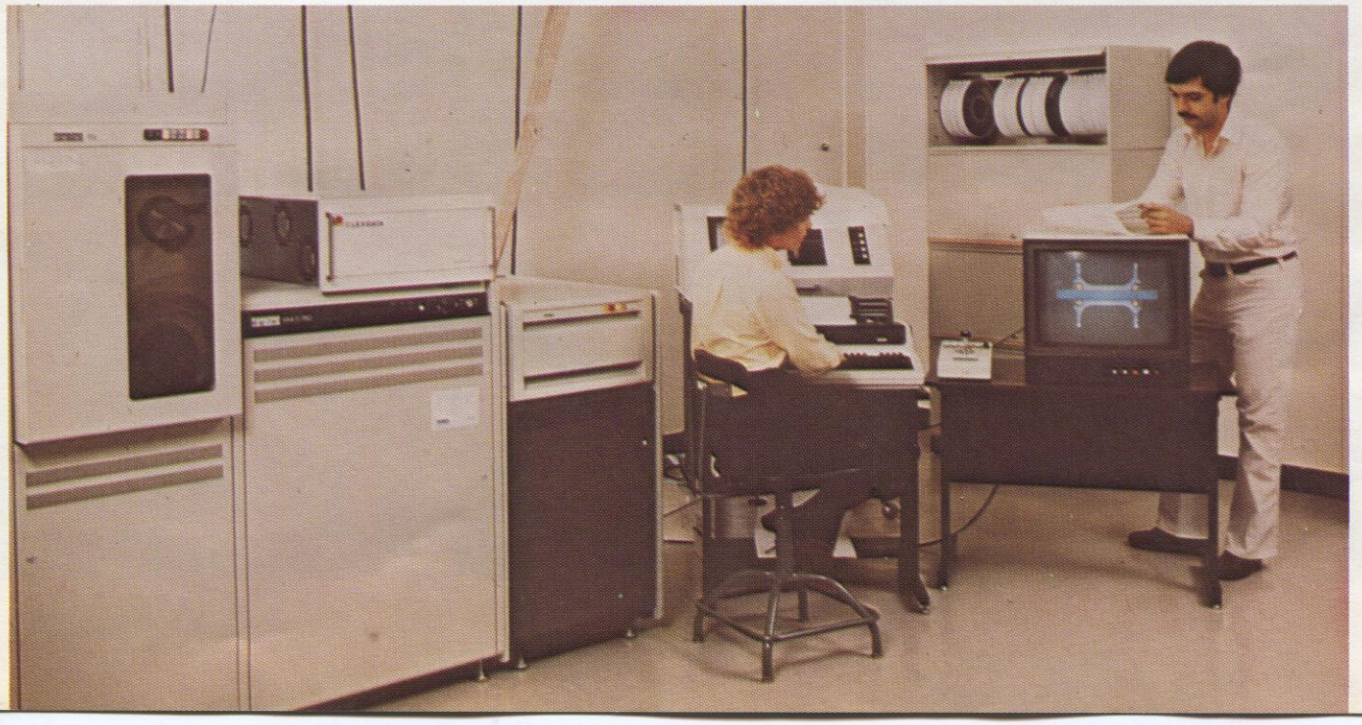
A new solid modeling technology called "SOLIDVIEW" from Lexidata Corporation, Billerica, MA, combines specific hardware and firmware, reducing from minutes to seconds the average time required to display a solid image.

SOLIDVIEW can display the construction of a solid object incrementally, without sequentially repainting the entire screen in scan-line order. It incorporates local-hidden-surface removal and visible-surface shading, to accelerate shaded-image generation.

Traditional approaches used today

Traditionally, object data from the host-computer data base is processed completely by the host computer, and transmitted as pixels to the display processor. The host computer has to transform and clip the

'SOLIDVIEW' enables user to work with solid-modeling software in an interactive environment. High power and speed allow incremental construction of solid objects in essentially real time, improving solid-modeling capabilities with minimal software effort. Driven by host computer, such as Digital Equipment Corp.'s. VAX 11/750 as shown, SOLIDVIEW comprises 12-slot chassis, monitor and joystick.



object into a viewing volume, remove hidden surfaces, and calculate pixel values for each visible surface.

Usually, the entire image has to be created at the host before pixel data is sent to the display processor. The result is a long delay before the first pixel is sent, and then the image appears one scan line at a time. The display processor acts only as a frame buffer to store the resultant image.

This approach is heavily unbalanced and host-computer-intensive. Even after much computation by the host, the image comes up slowly, since it is transmitted pixel by pixel.

Interactive solid modeling

While the host computer still performs the viewing transformation and volume clipping, the rest of the work is done by SOLIDVIEW. Working from 3-D polygon data that include shades at the polygon's vertices, the SOLIDVIEW removes hidden surfaces and displays visible surfaces with smooth shading interpolated from the polygon data. Since these operations are done in the bipolar processor, they are at speeds greater than with a host computer.

Works with host computer

Besides providing local computing power—especially important for solid-image display—SOLIDVIEW allows parallel processing with the host computer.

As soon as the first polygon is ready for display, data is transmitted to the solid-modeling system, and displayed immediately with hidden surfaces removed and visible surfaces shaded. This parallel processing saves a large amount of time.

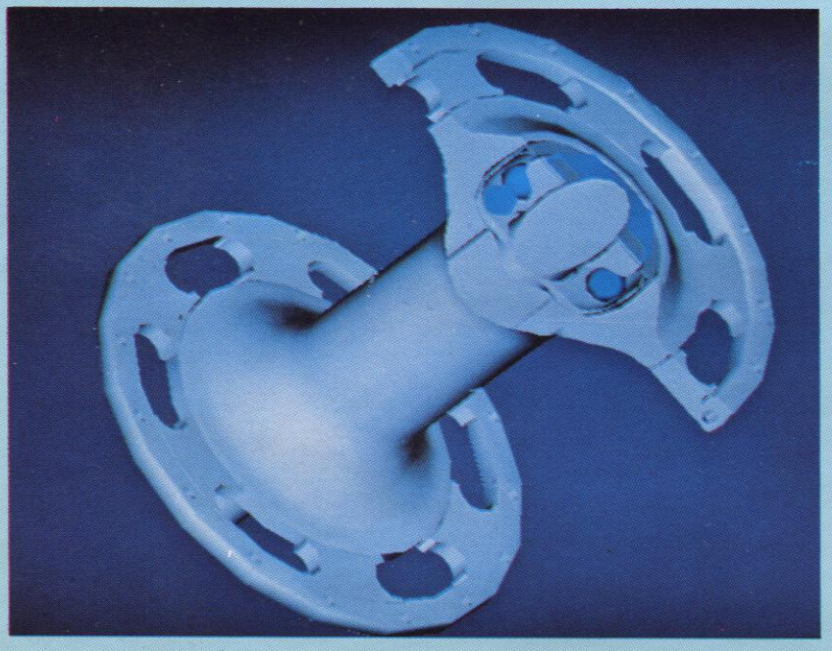
Data-storage requirements cut

Since the solid-modeling system can handle 3-D data directly, the host computer does not have to use hidden surface removal and visible shading algorithms. These procedures typically require pixel-by-pixel generation of the entire image before transmission to the display processor. Thus, the need for host memory commensurate with the displayed image (often larger than 1 Mbyte) is eliminated. In turn, smaller memory requirements eliminate the need for an expensive host computer.

The polygon data structure used by the solid-modeling system encodes information very compactly. This results in reduced loading of the host I/O channels, which provides greater throughput and allows other tasks to run without degradation.

Variable surface shading

Three types of surface shading are



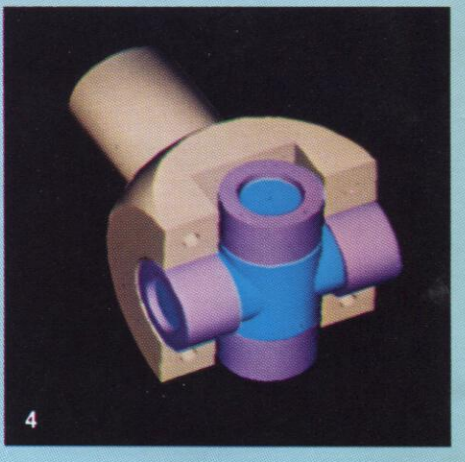
Sectioning of bicycle hub. Host computer defines cutting plane and Lexidata SOLIDVIEW solid-modeling system incorporates plane as it determines which surfaces are visible. Only objects or parts of objects behind cutting lane are displayed by solid-modeling system.

Host computer simply defines cutting plane, then transmits same polygon data that created model. The rest is automatic, completing section view in seconds.

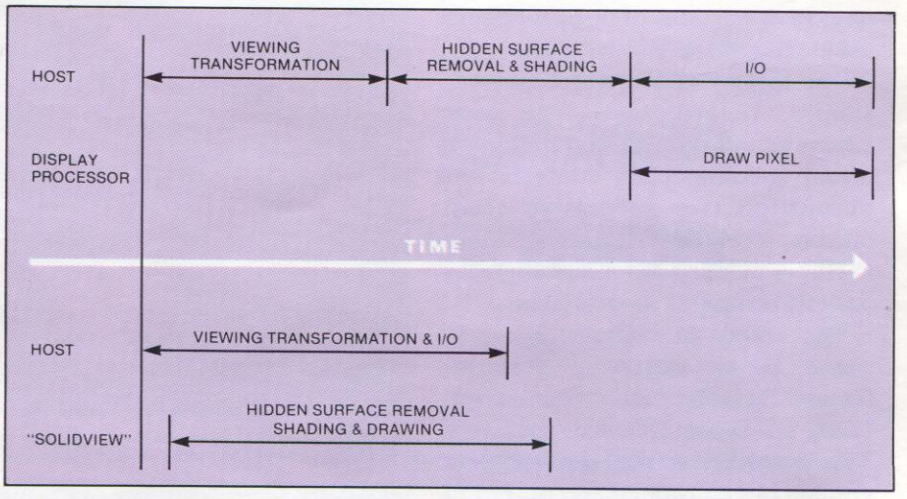
New sectional view can be created from same information simply by changing cutting plane; host computer doesn't get involved with actual sectioning.

Incremental solid modeling of common universal joint. Incremental construction feature of Lexidata SOLIDVIEW allows user to view object as it is being assembled, as opposed to waiting for entire object to appear line-by-line as with traditional solid-modeling displays. SOLIDVIEW lets user make necessary changes, interactively, as object is being constructed.

Completed universal joint (last photograph) consists of approximately 3000 polygons, yet took less than 5 seconds to generate.



SOLIDVIEW speeds solid modeling. In traditional solid modeling, host computer action is required from time operator requests new picture until it appears on screen. SOLIDVIEW technique developed by Lexidata almost eliminates any waiting: host computer produces drawing element on screen immediately.



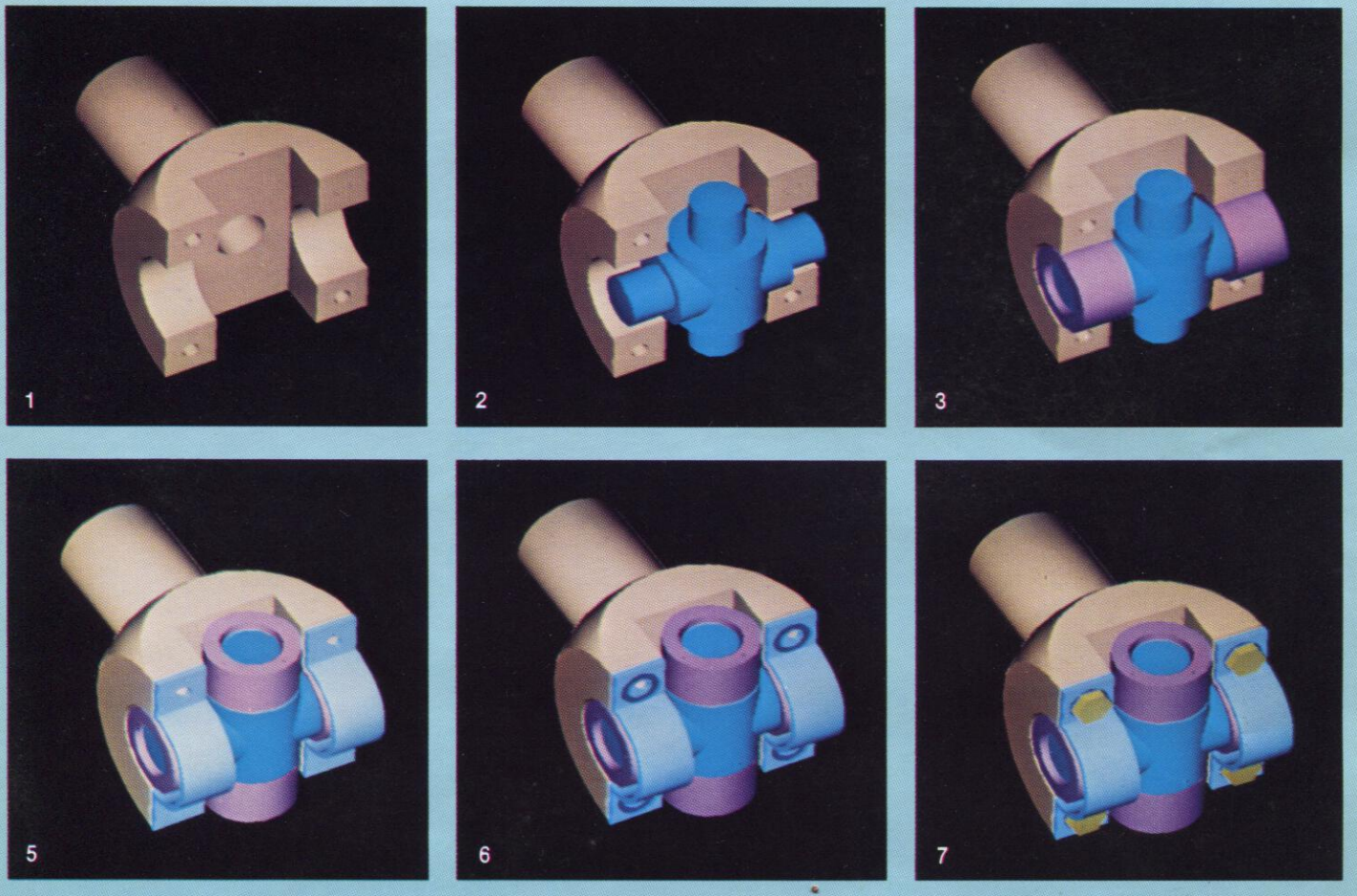
provided. The first is constant (polyhedron) shading in which each polygonal face is given a constant shade. While this involves less computation, it results in a shaded image in which each visible polygonal facet is clearly distinguishable.

The second type of shading allows intensity interpolation (Gourand shading) between polygon vertices, resulting in a smooth variation in intensity across an object.

The third is normal-vector interpolation (Phong shading), which also results in smooth shading.

Unique interactive features

The SOLIDVIEW approach has several interactive features that are *not* possible with other methods of display. For example, by using a graphic input device to position a cursor on the display, all three coordinates (X, Y and Z) of the visible surface element are available to the host computer. Cross-sectional views can be created without host-computer computation. The host computer defines a cutting plane and transmits the model; only



objects or portions of objects behind the cutting plane will be displayed.

The display of piercing objects is simple, regardless of the data structure and algorithms used by the actual solid-modeling software. In outputting two successive solid objects, local hidden surface removal shows piercing automatically with no host computer involvement.

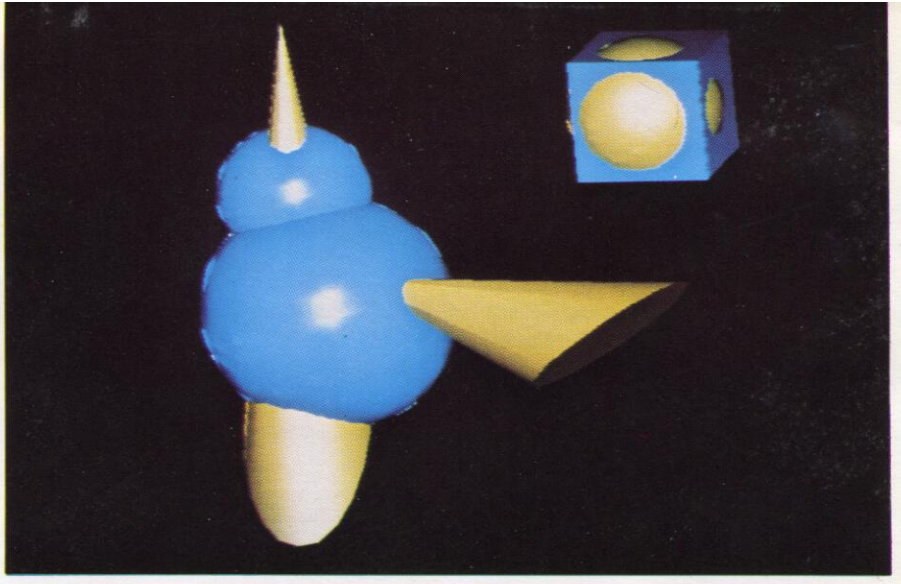
The ability to implement a 3-D cursor is an extremely powerful feature for solid-model interaction. Using a 3-D input device (such as a 3-D joystick), a user-defined 3-D graphic can be rotated and moved in three dimensions. As the cursor pierces or goes behind the object, it becomes partially obscured or vanishes, providing instantaneous 3-D visual feedback as the user interacts with the solid model.

Raster display

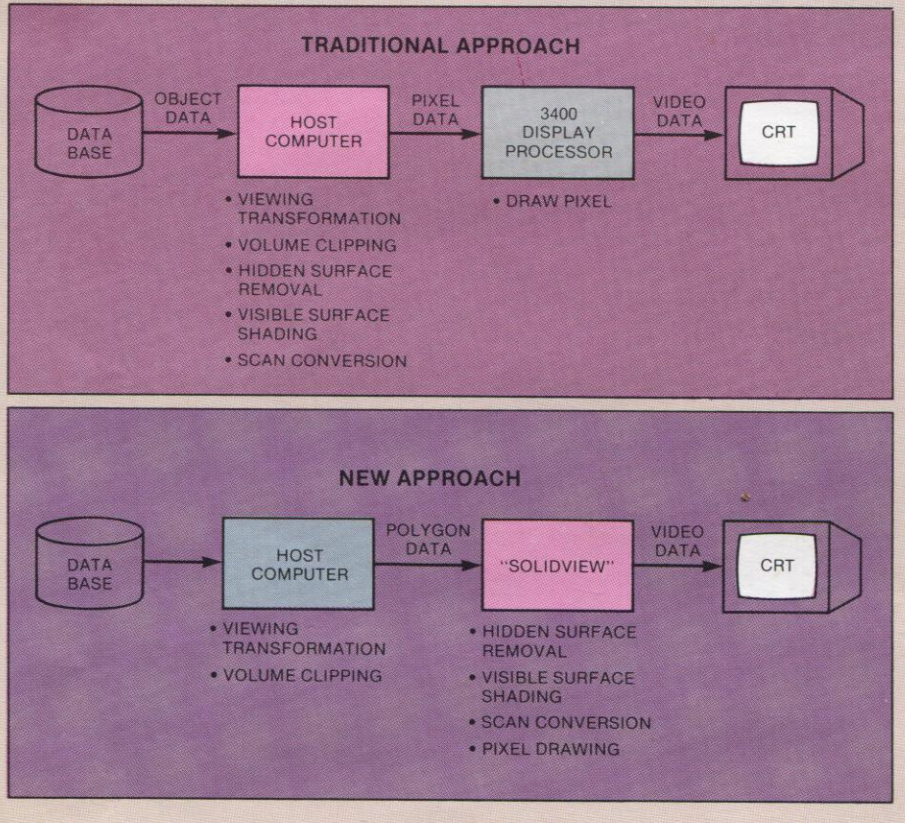
The raster displays compatible with SOLIDVIEW are available in two basic configurations. The first, 640 × 512 pixel display with 12 image-memory planes, and a 12-bit-in/8-bit-out/color, color-lookup table produces shaded image displays with up to 4096 simultaneous colors from a spectrum of nearly 17 million colors.

The second, a 1280 × 1024 pixel display with eight image-memory planes, and an 8-bit-in/8-bit-out/color, color-lookup table offers up to 256 simultaneous colors at high resolution from the same large color palette.

For additional details contact John Ricciardone, Marketing Communication Specialist, Lexidata Corporation, 755 Middlesex Tpk., Billerica, MA 01865, 617-663-8550. □



Piercing objects. Intersecting of objects does not require host computer calculation.



Traditional approach vs. new Lexidata approach to solid modeling. In traditional approach, host computer retrieves object data from storage medium, then performs viewing transformation, volume clipping, hidden surface removal, visible surface shading, and scan conversion. (Image is actually generated pixel by pixel in host computer.)

After this slow process is complete, host computer sends image pixel by pixel in scan-line order to display processor, which is used only as frame buffer to store picture (display processor performs no computation). Very high bandwidth is required to transfer this low-level data, thus tying up valuable resources of host computer.

In contrast, Lexidata SOLIDVIEW solid-modeling technique offloads host computer and balances computation load. Host computer performs only transformation and clipping functions and sends much higher-level data (such as polygons instead of pixels) across communication lines to solid-modeling systems.

SOLIDVIEW performs hidden surface removal, visible surface shading, scan conversion, and pixel drawing locally. A much smaller bandwidth is required, making communication significantly faster between host computer and display processor.

Reprinted from **DESIGN NEWS**, July 1983