Virtual Reality is the Real Deal
for Visualization Applications

by Kent Misegades, CEI President

From its beginning in 1994, CEI has kept an eye on developments in virtual reality (VR). As 3D tracking devices, input devices, and new display technologies matured, CEI has been at the forefront of integrating VR capabilities into its family of products. This article is a look at VR and how it is being implemented to help CEI customers better analyze, visualize and communicate engineering and scientific results.

The Components of Virtual Reality

While the VR realm is very broad, only a number of the related technologies are considered mature enough to be used in commercial software without requiring additional programming or specialized skills. Components of this technology currently implemented in CEI's products include:

- 3D viewing
- 3D input device
- head's-up macro (HUM)
- multi-frustum viewing
- parallel rendering

3D Viewing

A variety of methods can be used to turn a 2D display into a 3D display. The most common is stereoscopic viewing. Models are drawn, or rendered, for the viewer's left and right eyes separately, using a slight angular offset in either direction. The resulting pair of images are displayed or projected onto a viewing surface, alternating at a high rate between the left- and right-eye images.

Active stereo eyewear synchronizes the opacity of the left and right LCD lenses via an infrared transmitter attached to the computer's graphics processor. *Passive* stereo eyewear relies on two projectors or overlaid display surfaces and polarized lenses to filter the correct image to the correct eye. Either active or passive eyewear can be used in conjunction with CEI's software. (see figures 1-2)

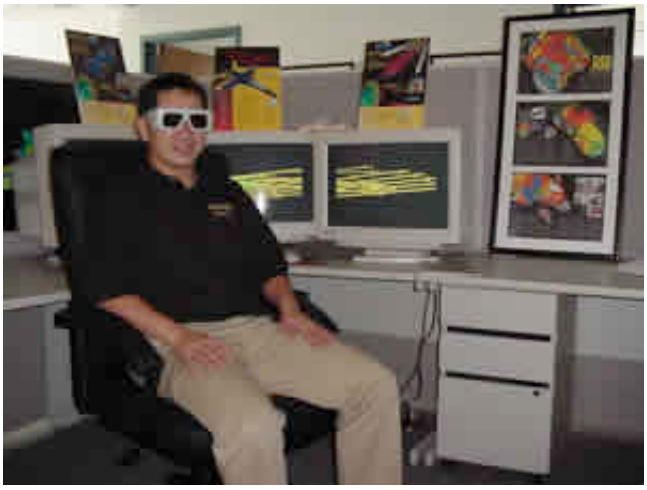

Figure 1: NuVision active stereo eyewear, stereo image on Sun multimonitor display.

Figure 2: 3D stereo image projected onto 3Dims display.

Users of EnSight and EnSight Gold can activate stereo viewing by toggling the F12 key. The separation angle between the left- and right-eye images can be increased by depressing the F11 key and decreased by depressing the F10 key. Models can be displayed in stereo either in the normal graphics window or in full-screen mode by depressing F12 followed by F9 (full-screen toggle).

Animations created in EnSight or EnSight Gold that are saved while in stereo mode to the EnVideo (.evo) format can be replayed in stereo
in EnVideo. Models displayed in EnLiten can be viewed in stereo by selecting Options -> Stereo.

3D Input Device (EnSight Gold only)

Most VR environments attempt to immerse viewers in the scene they are observing. These environments take many forms, including desktop stereo; simple back-projected displays; single- or multiple-surface "immersive workbenches"; large, multiple-screen theaters; and fully immersive rooms where models are projected on two or more angled walls.

In most cases, users require a way to manipulate (rotate, translate, zoom) their models. They also might want to interactively interrogate their data, such as they can using EnSight's interactive tools (particle traces, clip planes, flipbooks, etc.). Since the common means of interacting with software - mouse and keyboard - detract from the immersive nature of VR, an alternative means of user input is needed. In EnSight Gold, two features are available for this purpose: a 3D input device interface and a head's-up macro (HUM) facility.

There are a wide variety of 3D input devices, also called six-degree-of-freedom (6DOF) devices. They all make use of tracking hardware to continually provide information on their position and orientation. In addition, most provide one or more buttons similar to those found on a normal mouse. Devices take a wide variety of forms, including styluses, wands, cubes and gloves
(see figures 3-5).

Figure 3: Murray Consulting's Wanda 3D input device.

Figure 4: Fakespace PINCH glove.

Figure 5: Logitech TrackMan 3D input device.

Access to 3D input devices in EnSight Gold is provided through an application programming interface (API) provided with the software and found in the directory $ENSIGHT7_HOME/user_defined_src/input. A README file describes how this API is used. Several examples are provided, including an interface to the commercially available device library trackd from vrco (www.vrco.com). Users of trackd will be required to obtain a license for the library prior to using it with EnSight Gold. Trackd is considered a standard in the VR industry, providing links to most 3D input devices. Details on using trackd in EnSight Gold can be obtained from CEI or its distributors.

A 3D input device must be activated in EnSight Gold before it can be used. It can be activated in the following manner: Edit -> Preferences ->User Defined Input -> User Defined Input Device. (Note that 3D input devices are not available for Windows-based systems.)

Head's-Up Macro (EnSight Gold only)

Even the most sophisticated 3D input devices provide limited means to change the viewing scene, or the attributes of what one is observing. Typical scene changes include model part colors or visibility, starting an animation, or loading a second case. While it is possible to change the scene using normal mouse and keyboard selections in the EnSight GUI, a more elegant solution is provided by the HUM.

The HUM consists of one or more user interface panels that appear on the display. The macro panel interface is a user-defined menu of macros that appears within the viewing environment. Each button of the interface is

tied to a macro, itself being one or more commands in the EnSight Command Language (fully documented in the software). Buttons on the macro panel are selected using either the mouse or an activated 3D input device. The user defines the buttons of the macro panel interface in a file named hum.define that should be created by the user and placed in the .ensight7/macros directory. An example of this file may be found in the directory $ENSIGHT7_HOME/user_defined_src/input/HUM. The macro panel's size (# rows and # columns of buttons), dimension, initial position, color, and which macros are tied to which buttons are defined in the file hum.define. The macros themselves must be located in the same directory.

The second type of HUM interface is the part panel interface. It provides a list of model parts that can be selected in the same way as they are from the parts list found in the EnSight GUI.

The third type of HUM interface is a slide bar that appears for each interactive part, such as clip planes or isosurfaces, for example. The values defining these parts can be modified interactively, as they would be from within the EnSight GUI.

All three types of HUM interfaces can be repositioned and scaled while in annotation mode. (see figure 6)

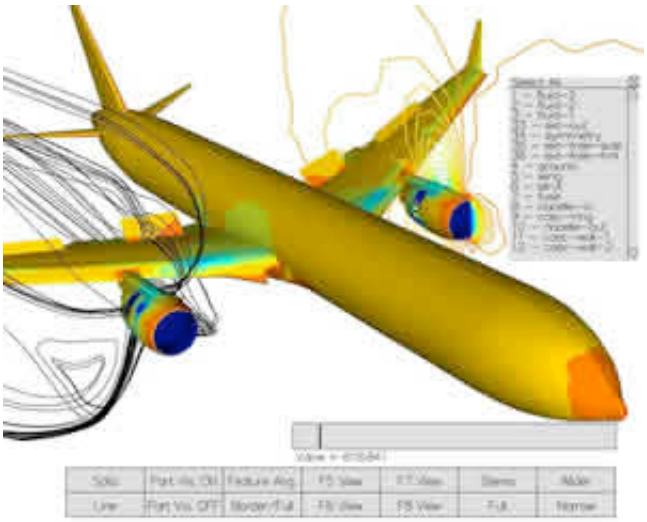

Figure 6: EnSight Gold's HUM: macro panel interface at bottom, slide bar for pressure contours above it, part panel interface upper right.

The macro panel interface and the part panel interface are activated from within the EnSight GUI: Edit -> Preferences -> User Defined Input -> Macro Panel Interface/Part Panel Interface. The slide bar interfaces appear automatically for each interactive part. More information on the HUM panels can be found in the EnSight User Manual. (Note that the HUM is not available for Windows-based systems)

Multi-Frustum Viewing (EnSight Gold only)

A view frustum defines what EnSight's "camera" sees and displays. Imagine a conical volume with its apex at the eye of the observer and intersected by two planes normal to the cone's axis and located at some distance in front of and behind the model. These planes are the near and far clipping planes.

When using the software on desktop displays or flat screens, only a single view frustum is necessary. But, if projection surfaces are angled with respect to each other, such as in the corner of a room, two view frustums are required. A six-sided display, generically referred to as a CAVE, requires six view frustums.

EnSight Gold supports multi-frustum viewing. Using a configuration file provided for each unique environment, the software creates the necessary frustums, rendering only the appropriate section of the model per frustum per display surface. When combined with stereo viewing, the result is an immersive experience that cannot be obtained using flat displays. (see figure 7)

Figure 7: EnSight is being used with a RAVE panel at NASA Glenn Research Center.

EnSight's multi-frustum viewing feature is very flexible and can support virtually any multi-paneled display. It can be used in conjunction with stereo viewing, 3D input devices, the HUM, and parallel rendering. For details, contact CEI or its distributors.

Parallel Rendering (EnSight Gold only)

Just as parallel CPUs accelerate numerical computations, multiple graphical processors accelerate the rendering of a given scene. The user senses this through quicker model transformations (rotate, translate, zoom).

Until recently, only the multi-pipe ONYX systems from SGI provided the multiple graphical processors necessary for parallel rendering. CEI, working closely with SGI, has optimized EnSight Gold for operation on ONYX systems containing more than one graphical pipeline (so-called "monster" mode on SGI systems). This feature can be used in conjunction with stereo viewing and multi-frustum viewing. If a system contains four pipes and a two-panel display system is used, for example, each display would make use of two pipes. EnSight Gold users have complete control of ONYX pipeline allocation. (see figure 8)

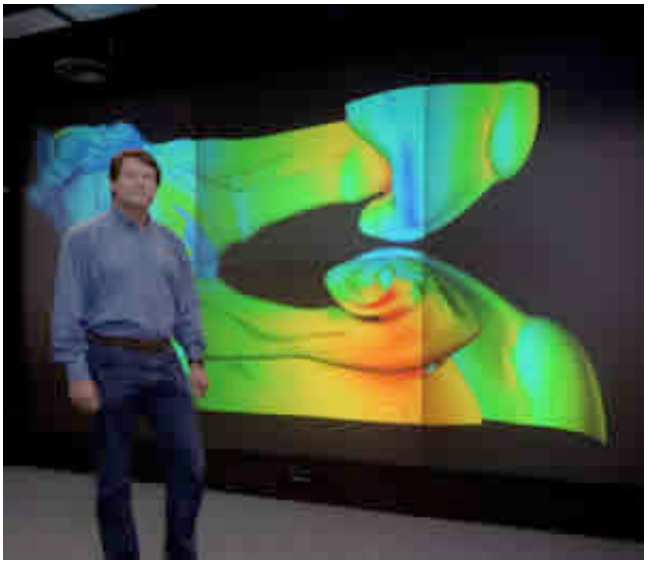
Figure 8: Parallel rendering: Multi-panel wall display driven by six-pipe SGI Onyx system at LANL.

More recently, other hardware suppliers such as Sun Microsystems have released products with multiple graphical pipes. EnSight Gold also takes advantage of these systems. HP, SGI and Sun all have "transparent" multi-pipe systems that require no additional optimization to realize parallel rendering. Performance gains for such transparent solutions are less than for optimized implementations, however.

Parallel rendering performance improvements will not, in general, be realized when using multiple graphics pipelines for multi-frustum applications such as CAVEs. For details on configuring EnSight Gold for use on multi-pipe systems, contact CEI or its distributors.

Virtual Reality Suppliers

VR environments vary widely and include stereo (3D) viewing on computer monitors, back projected large-screen and panoramic systems, semi-immersive virtual desks and benches, fully immersive CAVEs, and others. This article does not attempt to describe brand-name VR hardware. Information from suppliers can be found on the following web sites:

www.ascension-tech.com
www.evl.uic.edu/cavern
www.cs.unc.edu/research/vrpn
www.isense.com
www.logitech.com
www.nuvision3d.com
www.panoramtech.com
www.polhemus.com
www.sgi.com
www.stereographics.com
www.tan.de
www.vrco.com
www.3dims.de

VR Features of EnSight and EnSight Gold

Except for stereo viewing, the VR components described in this article are supported only by EnSight Gold. To enable these features, your license of EnSight must include one or more Gold seats, and you should start the program with the command line option -gold.

VR Features of EnVideo and EnLiten

VR systems are intended more for data display and occasional scene modification, not detailed post processing. For this reason, tools such as CEI's EnLiten and EnVideo might be better suited than EnSight for VR applications.

EnVideo displays EnVideo-format (.evo) animation files created in EnSight. Since it supports stereo viewing, EnVideo can be used for simple, flat-panel VR environments or on computers and monitors capable of supporting stereo.

EnLiten displays model geometry and animations saved in EnSight as EnLiten Scenario (.els) files. As with EnVideo, EnLiten supports stereo viewing, and provides users with the means to start and stop animations. It also allows full model transformations (rotate, translate, zoom) as in EnSight. EnLiten will provide support for 3D input devices in 2002.

Both EnVideo and EnLiten are available free of charge from CEI's web site. Both products provide simple controls and require no training, making them ideal for the non-specialist. EnLiten Gold, which can be obtained at a moderate price, incorporates EnSight Gold's advanced VR features such as multi-frustum viewing and parallel rendering.

The Future of VR at CEI

VR is no longer considered an exotic way to display data in science and industry. As the cost of VR systems

has declined and software such as EnSight, EnVideo and EnLiten has become available, VR has found its way into the normal toolbox of scientists and engineers. CEI is continuing its research into VR, and exploring related technologies, including:

- Head tracking - where the display follows the motion of the observer's head
- Voice recognition - perhaps more efficient than a HUM
  Haptic devices - to provide touch feedback to a 3D input device
- Inexpensive parallel rendering - using arrays of commodity graphics processors (so-called Beowulf clusters) to accelerate rendering of large models
- Improved user-interaction techniques

CEI customers can expect this ongoing research to find its way into future products.
