Merging 3-D Imaging and Holography

The beauty of three-dimensional graphics packages used by engineers and scientists is that a viewer can not only see an image in depth from different angles but can also manipulate it with software. The resolution of the image, however, is limited to the resolution of the graphics program, or of the screen on which the graphics are viewed, which is typically megapixels at most. Holograms, on the other hand, can contain terapixels of data and are inherently 3-D. But because these holographic images are fixed in the holographic film, the viewer cannot manipulate the image or interact with it, except to view it from different angles.

But now, a research group at the Bauhaus University in Weimar, Germany, has developed a method for combining the interactivity of computer graphics with the data richness of the hologram by superimposing the holographic image and the 3-D graphics image.

To understand how the Bauhaus University's method works, consider how a hologram is made and how it re-creates a 3-D image of an object. To make a hologram, laser light is split into two light waves that are initially in phase. One of the waves illuminates the object to be imaged, and the light reflected from the object travels to a holographic film. The second light wave, the reference wave, falls directly onto the film. Because the distance that the first light wave travels varies according to where it strikes the object, it will generally arrive at the film out of phase with the reference wave. The amount by which it is out of phase depends precisely on where it strikes the object.

The two out-of-phase light waves create an interference pattern on the film. And this interference pattern contains all of the information needed to re-create a high-resolution image of the object when a third light wave strikes the hologram at the same angle as the reference wave that helped to create it. In most holograms, white light, typically from a halogen bulb, rather than laser light, is used to re-create the image.

To create the superposition of the two images, the Bauhaus University researchers mainly use three pieces of equipment: an autostereoscopic display, which allows viewing of 3-D graphics without the use of special glasses; a white-light hologram; and a digital projector, such as one used to display presentations stored on a computer onto a large screen.

The autostereoscopic display shows images of 3-D graphics through a plastic sheet of tiny lenses that direct a different image to each eye. The holographic film is directly attached to the front of the display screen. When the digital projector illuminates the hologram, the re-created 3-D images from

the hologram and the display appear to the viewer in the same volume of space.

But the technique would be of little use, says project leader Oliver Bimber, a junior professor at Bauhaus University, if it only projected the total holographic image on top of the 3-D graphics image, because the holographic image would simply overpower its 3-D graphics counterpart.

The power of the technique, he says, comes from the ability to control the direction and intensity of the light from the digital projector, and thus to control which parts of the hologram are re-created and which are not. So if a paleontologist is viewing the graphical image of a dinosaur's soft tissue inside its skull, the digital projector illuminates only those parts of the hologram that do not cover up the soft tissue. If the position of the tissue is shifted, the system automatically adjusts which parts of the hologram the projector lights up [see image].

In this way a researcher can use the very high-resolution information contained in a hologram to help create a 3-D model of soft tissue produced by computer graphics. In the example here of the dinosaur skull, the paleontologist needs to see the fine details of the bone structure to find where the muscles were attached. And so far, says Bimber, such resolution is not possible with conventional autostereoscopic 3-D displays. So paleontologists have to work with physical fossils instead.

Bimber sees other applications as well. He and his research team are working with DaimlerChrysler AG, Stuttgart, Germany, to apply the technique to the design of cars. *—Linda Geppert*