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The rise and rise of the holographic printer

by Sunny Bains

The time has come for display holography to make its mark. Not through tacky silver holograms with suspect imagery, novelty key rings, or even subtle artworks that people have to travel miles to see...but through the holographic printer: the "killer app" that holographers have been working on for years. Though at very different stages of development, four groups of researchers have demonstrated holographic printers that work and that seem to have few serious technical problems to overcome in order to commercialize them.

Seeing in stereo

Three of the four groups are working with holographic stereograms, which use stereopsis to provide 3D in much the same way that so-called "virtual reality" headsets do. Two different, flat, images are presented to the viewers' left and right eyes, fooling them into thinking that they can see depth. Stereograms consist of hundreds of vertical slit holograms, recorded sequentially on a holographic plate, each of which is a window to a different view. As viewers move from left to right, the successive views allow them to see parallax.

Though it's not yet commercial, in the sense that no-one's trying to develop it into a "product" yet, the work at MIT's Media Laboratory (Cambridge, MA) is the most developed. Led by Professor Stephen Benton, researchers at the Media Lab have spent years on issues such as color control and the predistortion of computer-generated views to make up for an imperfect optical system. Not to mention the fact that today's stereograms were more-or-less invented there. The most critical change was away from the classic two-step stereogram system, which required that three holograms be made (one for each color) and then transferred into a fourth hologram. This involved using a more complex optical design, including computer-generated holographic diffusers to fill each slit hologram easily and allow a decent vertical viewing angle.

The current one-step system, built by research scientist Michael Klug, allows them to make full-color holographic prints, including rendering, in 30 minutes. They have also developed a camera system that allows them to collect perspective views for portraits--250 of them--in just 7 seconds. Printing out the hologram in monochrome takes just 10 minutes (Figure 1).

Squaring the problem

At the Tokyo Institute of Technology (Yokohama, Japan), researchers have taken the one-step stereogram a step further. Though their holograms are monochrome and, perhaps, the least impressive to look at, they have full-parallax. Conceptually, this is no different than a classic stereogram. Instead of using elemental slits, however, the Japanese group uses an array of tiny rectangular holograms (see figure 2). The columns still work as slits in terms of the stereo 3D effect, but now the viewer sees different views, over and under the object, as he or she moves up and down. That's an advantage, of course, but a costly one.

Depending on the particular case, this can more or less square the number of perspective views to be rendered. Producing 200 images can already be a pain, but rendering 40,000 is almost certainly impractical. If they can get around it though, there are compensations. Because the holograms are smaller, they don't take a lot of energy to record. With a reasonably powered laser beam, therefore, the exposure time--per hologram--can be kept to a minimum. This technology also lends itself to writing many holograms at once: necessary if you have to record tens of thousands of images to produce one print.

Masahiro Yamaguchi, Research Associate at Tokyo Institute of Technology, says the group doesn't currently have a concrete commercialization plan for the printer, but they're expecting to start working on one soon. Their current project has been to capture enough data with a video camera to make prints of real subjects.

Given the huge quantity of very specific data needed to produce this kind of hologram, this is not an easy project to undertake for a full-parallax printer. How they may have solved this problem, however, is so far unknown. The results, says Yamaguchi, will be reported soon.

Front runners

The group that is closest to producing a commercial stereogram printer is Dutch Holographic Laboratories (DHL, Eindhoven, Netherlands). The design is now at such an advanced stage that more people are now working on the "Office HoloPrinter" mechanical design than on the optics (See March OE Reports, page 14). Walter Spierings, chief researcher and head of DHL, is pushing hard because he hopes to have a product ready for beta testing within four months. They should have a printer on the market, he says, soon after that. Color is also on its way, but not the priority. Spierings expects it will take six months before DHL has a color prototype ready.

In the meantime, they have to get the monochrome printer ready for the real world. DHL engineers have recently had to concentrate on issues such as the design of a film-transport buffer, which allows a huge roll of holographic film to be exposed, bit by bit, without stresses building up in the material. Also crucial was the development of a new algorithm that speeds up the rendering time for the perspective views by four or eight times. This is important because DHL's machine can produce an A4-sized (210 x 297 mm) hologram (see figure 3) in about fifteen minutes, but only off a memory. On-the-fly computer graphic rendering is still too slow.

However, the most commercially advanced holographic printer to date does not use stereograms at all. VOXEL (Laguna Hills, CA), has designed a slice-stacking holographic system to allow doctors to view full sets of MRI and CT scans together. Though set up as a bureau service at present--doctors send their data either on disk or over the net and then receive a hologram back through the mail--a black-box system is almost ready to go into beta testing. VOXEL intends to market their printer as a peripheral to the (extremely expensive) medical scanners that hospitals already own.

Both doctors and money-men have already been convinced that this technology is useful: there have been many favorable articles in the medical press and the company was successfully floated on the stock market in 1994. However, the VOXEL printer will almost certainly be limited to the very small (though lucrative) niche market they've carved out. The holograms it prints have the advantage of being extremely faithful to the original scans, which is what doctors want, but they are inherently single-color, don't allow occlusion, and have to be viewed using a special light-box. Stereograms can have color, require no special equipment for viewing, and are more compatible with standard computer graphics.

On the brink

None of these groups has it all figured out. The Media Lab has a great little printer, but it is only designed to live in an optics lab. The Tokyo printer, though potentially producing the most comprehensive 3D, is not currently compatible with the speed of today's computers. DHL's is the most practical and prints the biggest holograms, but doesn't have color yet, and that may be a serious drawback to many customers. VOXEL has its niche market, but is not looking for anything more. What is striking, however, is that all these groups are basically pushing in the same direction.

Though the market isn't as neatly defined for the stereogram printers, there is no shortage of people with possible applications. For instance, Robert Andrews, CAD/CAM Coordinator in Cross Vehicle Design Engineering at Ford's Product Development Center (Dearborn, Michigan) is looking into ways for Ford to speed up its design process without giving up the ability to review each design in 3D.

According to Andrews, the only way to display volumetric CAD data in real 3D is to build a physical model (by hand or multi-axis milling machine) or to print out a hologram from the computer application. He believes that using holography in the design process is very cost effective and saves time. And this is not just idle speculation. Andrews is actively assessing the work of holographers all over the world, as well as embarking on one or two joint projects with holographic companies.

Sunny Bains is a technical journalist based in Edinburgh, Scotland.