Images in Space

Although it’s completely natural for humans to see in three dimensions, most displays can still show only two-dimensional images. Nevertheless, some 3D displays have been developed, and their potential applications range from chemistry labs to Internet shopping and 3D television.

In a familiar scene from Star Wars, Luke Skywalker is busy repairing the robot R2-D2, when suddenly a 3D image of Princess Leia appears before him. As it happens, she has actually mistaken Luke for someone else: “Help me, Obi-Wan Kenobi, you are my only hope!” she pleads. In the realm of science fiction, 3D multimedia communications are rather old hat. So old, in fact, that such technology could soon be a part of our everyday lives. Indeed, some TV viewers are already familiar with 3D broadcasts, although these require the use of special glasses, and as a rule the results are less than impressive. But in the future, it should be easier to generate 3D images of a much higher quality.

In fact, it’s pretty simple to fool the human brain into thinking that it’s receiving a 3D image. Our eyes give a sense of depth to everything we see. This is because one eye focuses on the object in question at a slightly different angle than the other. The brain then combines the two images and calculates the distance to the object observed. Might not this principle be used for 3D displays? Screens that alternate at a frequency of 120 hertz between one image for the right eye and one for the left are relatively common today. Special shutter glasses prevent one eye from seeing the image destined for the other, so that each eye in fact sees only 60 images per second. The brain is unable to resolve this rapid alternation and therefore constructs an image in three dimensions. But how many of us want to wear an unwieldy pair of glasses to watch TV?

3D for Your Eyes Only. Considerably more comfortable are the auto-stereoscopic 3D LCD displays sold by major manufacturers such as Philips, Sanyo and Samsung and smaller firms like Germany’s Dresden-based SeeReal Technologies and 4D-Vision in Jena. Research institutes such as the Heinrich Hertz Institute (HHI) in Berlin are currently working to enhance this technology. The principle is simple. A grid of rod-shaped cylinder lenses or prisms is mounted in front of an LCD display. The grid directs the light from one row of pixels to one eye and the light from the neighboring row to the other eye. The viewer’s brain then combines the two images in such a way that a 3D effect is produced.

If the viewer moves forward or backward, however, or only a few centimeters to the right or left, the impression of depth deteriorates substantially. And it can even be reversed so that the horizon of the picture suddenly appears closer than the tree in the foreground. To correct this, special follow-up systems have been developed to move the grid of lenses to one side whenever the viewer moves his or her head. “But viewers instinctively keep still as soon as they notice that any movement diminishes the quality of the 3D effect. After an hour, they’re guaranteed to have a stiff neck,” explains Thomas Riegel, a researcher in multimedia communications at Siemens who closely follows the latest developments in the world of 3D displays. Another drawback of the movable lens grid is that it can only be used to compensate...

What looks like a scene straight out of Star Trek or Star Wars is in fact part of a medical technology exhibition at the SiemensForum in Munich.
for the movement of one person. On the other hand, fixed lens grids can be designed and mounted in such a way that a group of viewers — between five and nine, at present, depending on the manufacturer — can use such a screen as long as they don’t move.

3D TV. A number of companies are therefore looking at alternative 3D technologies, not least because there are certainly enough potential applications. At a meeting of the MPEG4 standardization group, held in the Japanese city of Awaji at the end of 2002, there were predictions that the next ten years could well see 3D technology usher in the next big revolution in the TV industry. Meanwhile in Europe, the ATTEST consortium (Advanced Three-dimensional Television System Technologies), a project involving European companies and institutes, is currently setting the stage. Any future 3D TV system has to be compatible with current 2D reproduction, and its implementation must be affordable. There is also big potential for 3D applications in the field of medicine. “We’ve been supplying surgical microscopes since the 1990s that enable physicians wearing shutter glasses to view the images on a 3D monitor,” says Peter Andrews, Sales Manager at German optics specialist Zeiss. “Autostereoscopic displays may well bring the definitive breakthrough here.” Because they show the physician the precise location of the surgical instruments, detailed 3D images would also be highly useful for minimally invasive operations.

Virtual Factories. In plant engineering, 3D imaging results in both cost and time benefits. Siemens, for example, uses large 180-degree stereo projection surfaces to generate virtual 3D representations of power plants, new factories and other large installations. “In the past, customers needed three to four weeks to check the plans for a new power plant — with virtual reality it now only takes three to four days,” says Dr. Detlev Teichmann, Project Manager for Production Processes at Corporate Technology. What’s more, this method is less costly. Several years ago it cost five million euros to produce a model of a new ICE high-speed train. A virtual projection would have cost only a fraction of that sum. Chemists, too, could make good use of 3D images — to view biomolecules, for example. And, last but not least, the Internet is bursting with potential applications. After all, people buying online like to take a good look at a product before purchasing — for instance in a virtual 3D shop. Naturally, software producers such as Adobe, Macromedia and others see big market potential for 3D chat rooms, where participants can select their own representative (avatar) and then move this figure at will with a computer mouse. In today’s chat rooms, a 3D effect is merely simulated through the mobility of the figures.

Laser Holography. Could holography be the key to 3D? This involves illuminating an object with a laser and then photographically recording the pattern that is produced as the reflected light interferes with a reference beam. Illuminating this interference pattern with a laser beam produces a 3D image of the object floating in space. Unfortunately, this process is really only suitable for small, stationary objects. In the 1990s, a technique known as electro-holography was developed at the Massachusetts Institute of Technology in Boston. The technique can even produce holographic videos, because acoustical-optical elements exert so much influence on the laser beams in real time that the overlapping waves generate a 3D image for the viewer. Thus it is also possible to produce 3D images of models stored in computers. However, there is still no satisfactory way to supply the computing power needed to process the massive data volumes involved.

An alternative solution was proposed back in the 1970s by Rüdiger Hartwig from the University of Heidelberg. This involves using colored lasers to illuminate a transparent helix of Plexiglas rotating at 1,200 revolutions per minute. At such speeds, the helix itself is invisible, so that only the points hit by the laser beams can be seen. If the beams

Internet shopping is one of many potential applications for 3D displays.
are moved quickly enough, it is possible to illuminate each point of the volume covered by the rotating helix, thereby generating a 3D image. Such a 3D display, which seemingly floats in the air, would be useful for monitoring air space, since air traffic controllers could then see both the course and the altitude of an aircraft simultaneously. This principle was first exploited in the mid-1980s and has since been developed by a number of companies.

Eyeing Projections. A new technique presented by the Heinrich Hertz Institute at CeBIT 2003 dispenses with the use of a screen-type device completely. Here, two small projectors are used to project a left-hand and a right-hand image directly into each of the viewer’s eyes. The viewer then sees a 3D object floating directly before his or her eyes. With the aid of a computer-controlled mechanical glove-like device, the user can even handle the image, move it around and feel its texture and consistency. This procedure is ideal for testing how people will react to a planned product. In other words, it is no longer absolutely necessary to build a model—all that’s needed is to convert design data into a 3D image. Similarly, the technology would also bring benefits for Internet users. In the virtual 3D shop of the future, for instance, customers will not only be able to inspect a comfortable new bed from every angle, but will also be able to feel its softness and quality. “One particularly interesting aspect of this technology is that the image is completely private,” explains Dr. Siegmund Pastoor from HHI. “Anyone standing outside the projection beam can’t see why the user is groping around in mid-air.”

And when will we be able to emulate R2-D2 and summon an image of Princess Leia to appear? “Sure, that would be possible,” says Siemens researcher Thomas Riegel. “It’s like creating a mirage. All you need to do is create a suitable boundary layer in the air—say, through a pressure or temperature gradient—upon which you can then scatter light.” Unfortunately, no one knows just how to manage that; but maybe George Lucas can suggest a solution.

In Brief…

- Important trends in lighting research include making light sources smaller, longer-lived, more efficient and more environmentally friendly. Future dividends could include the elimination of mercury from high intensity gas discharge lamps thanks to a better understanding of the physical-chemical processes in their interior and new electronic ballasts. (p. 35)

- Different light sources can be integrated into intelligent networks and combined with natural light in the “adaptive lighting” concept, which offers both energy savings and increased comfort. The sensors and communications standards needed for this are already available. Osram is also developing a discharge lamp in which LEDs are used to provide variable color rendition. (p. 37, 49)

- LEDs can achieve lifespans of up to 100,000 hours, and are being introduced into a growing number of applications, such as display panels, automobile headlights and flash units for cell-phone cameras. White LEDs could reach conversion efficiencies of 100 lumens per watt within ten to 15 years, opening the door to their use in general lighting applications. (p. 38)

- Annual growth rates of 17 percent and more could lead to LEDs having a market volume of around seven billion euros in 2007— which would correspond to 28 percent of the world lighting market. Opened in Regensburg by Osram in April 2003, the world’s most modern optical chip plant will enable the company to double its production capacity of optical semiconductor by 2005. (p. 42)

- Prospects for organic LEDs (OLEDs) are also bright. These self-luminous, high-contrast, extremely flat and video-capable plastics could revolutionize the market for displays. Osram recently established a mass production facility for OLEDs in Penang, Malaysia. (p. 45)

- A wide range of applications awaits displays capable of representing images in three dimensions. Examples include chemistry, factory design, and Internet shopping. Concepts are currently being developed. (p. 51)