Practical technology?

Nick Holliman, Lecturer at the University of Durham, explains digital stereoscopic imaging…

The basic principles of stereoscopic imaging have been known since Sir Charles Wheatstone first described them in 1838; however, modern electronic displays are allowing new levels of realism and interaction with digital stereoscopic images.

3D displays provide viewers with a binocular (stereoscopic) image. This type of display differs from a standard display by allowing each eye to see its own view of a 3D scene. The brain interprets the small differences between the two views as depth, and objects then appear convincingly, to the viewer, to be in front or behind the display surface.

Today's 3D display systems provide new advantages to users; they are able to support an auto-stereoscopic, no-glasses, 3D experience with significantly enhanced image quality over previous generation technology. There have been particularly rapid advances in personal auto-stereoscopic 3D display for desktop users brought about because of the opportunity to combine micro-optics and flat panel displays, coinciding with the availability of low cost desktop image processing and 3D computer graphics systems.

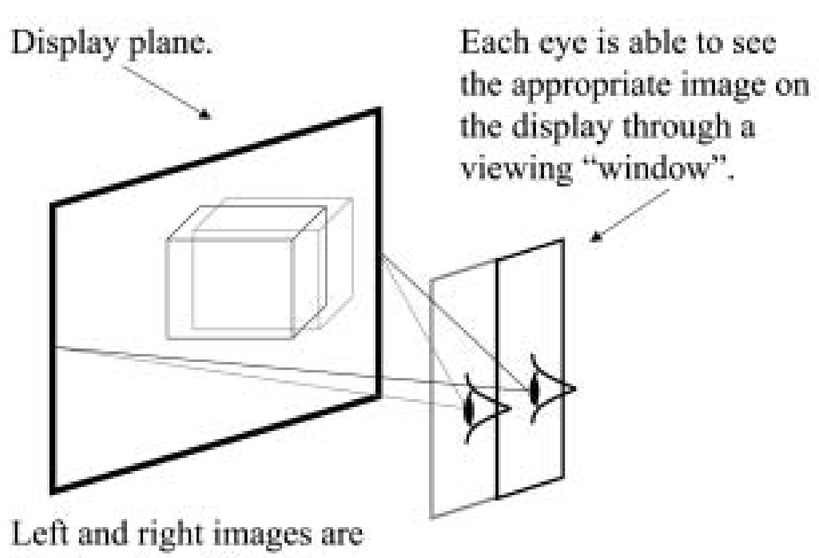

Fig. 1

Auto-stereoscopic 3D displays

Auto-stereoscopic 3D displays guide the left and right views to each eye without the need for the viewer to wear glasses or other devices. There are a number of optical technologies that achieve this effect and three of the most important competing designs are summarised below.

Two view auto-stereoscopic displays

Two view displays generate the two views for the left and right eyes in two viewing windows in space; see Fig. 1. These are primarily visible from a central viewing position and the user may have up to 20 or 30mm of movement around the central viewing position before they lose the 3D effect.

Typically, this type of display has high resolution per view and low cost. Some displays allow switching the display between 3D and 2D, allowing the display to function as a standard monitor when the 3D effect is not required.

Multi-view auto-stereoscopic displays

Multi-view displays provide more than two views simultaneously in multiple viewing windows, for example, there may be nine, 12 or more views; see Fig. 2. The viewer sees any two of these simultaneously and the views are arranged so that each simultaneously visible pair forms a valid stereo image. The key benefit of these displays is the wider lateral viewing freedom that this allows. They can also allow multiple simultaneous viewers.

Typically, modern displays of this type have low resolution per view as the underlying display must be divided into multiple views but they benefit from relatively low cost. Multi-view displays sometimes allow 2D/3D switching.

Tracking two view auto-stereoscopic displays

Tracking two view displays aim to provide the higher resolution per view of two view displays and the wide viewing freedom of multi-view displays; see Fig. 3. They achieve this by generating just two views and steering these to follow the viewer's head position. This requires a viewing window steering mechanism in the display and a head tracking mechanism linked to it to detect where the viewer is.

These displays provide high resolution per view and wide viewing freedom, but at the cost of requiring tracking and steering mechanisms. Currently, these displays do not normally have 2D/3D switching ability.

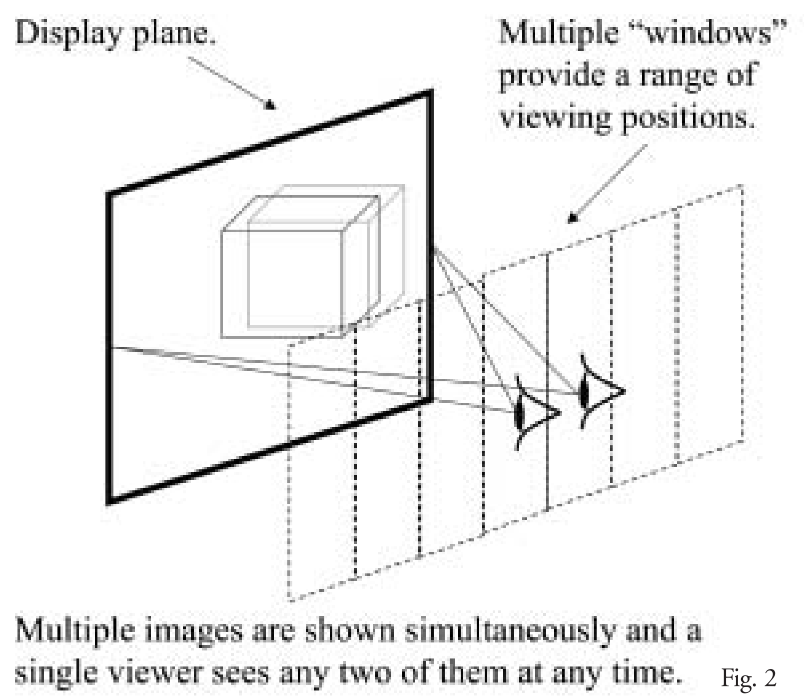

Fig. 2

Benefits of stereoscopic 3D

An important question is what advantages does binocular vision provide?

As a visual effect, it clearly fascinates the majority of people when they see a 3D picture. However, beyond the attractive nature of digital stereoscopic images, they are known to provide the following benefits over monocular vision:

- Relative depth judgement: The spatial relationship of objects in depth from the viewer can be judged directly using binocular vision. This is the basic depth effect that attracts viewers to 3D displays, and has been demonstrated over many years to entertain in films and, more recently, in computer games;
- Spatial localisation: The brain is able to concentrate on objects placed at a certain depth and ignore those at other depths using binocular vision. This helps in the interpretation of images with complex information content, for example, in medical imaging using volumetric data sets from CT and MRI scanners;
- Breaking camouflage: The ability to pick out camouflaged objects in a scene is probably one of the key evolutionary reasons for the development of binocular vision. This often motivates the use of stereo in security and military applications;
- Surface material perception: Lustrous, sparkling gems and glittering metals are seen as such because of the different reflections and refractions of light detected by the left and right eyes. This improves the realism of digital images of these objects and could, for example, enhance the experience of internet home shopping;
- Judgement of surface curvature: There is evidence that curved surfaces can be interpreted more effectively using binocular vision. This is in part why car companies now routinely use large-scale 3D displays in the design process.

These benefits make stereo image display of considerable benefit in certain professional applications where depth judgement is important to achieving successful results. For example, at the University of Durham, we routinely use digital stereoscopic images for interpreting 3D geological data and viewing 3D cosmological simulations. For consumers, the effect of stereoscopic depth is compelling enough that 3D displays have already formed the basis of entertainment systems, including arcade game systems and mobile phones.

Creating high quality stereo images

Good quality stereo image creation is still a skilled process. There are surprisingly few software tools to help and, as a result, you can find that images are not always well produced and may be hard to view comfortably. Reasons for this are related both to display quality and to human factors; for example, the depth effect seen in a stereoscopic image is dependent on the size of, and viewer's distance from, the 3D display it is viewed on, and ideally, each stereoscopic image needs to be created specifically for the display currently being used. Fortunately, this is an active research area and new dynamic stereoscopic camera models are appearing that enable content creators to generate stereoscopic images that are right first time, whichever display they are viewed on.

An important lesson that is now more widely understood by content creators is that just because you can see a stereoscopic image comfortably does not mean everyone else can. This is because stereoscopic visual ability varies and because, the more you personally use stereo, the more adapted you become to the effect. Therefore, if content is being created for novice audiences (particularly children), it is important to be conservative with the amount of depth effect used. It is always dramatic to use lots of 3D depth but

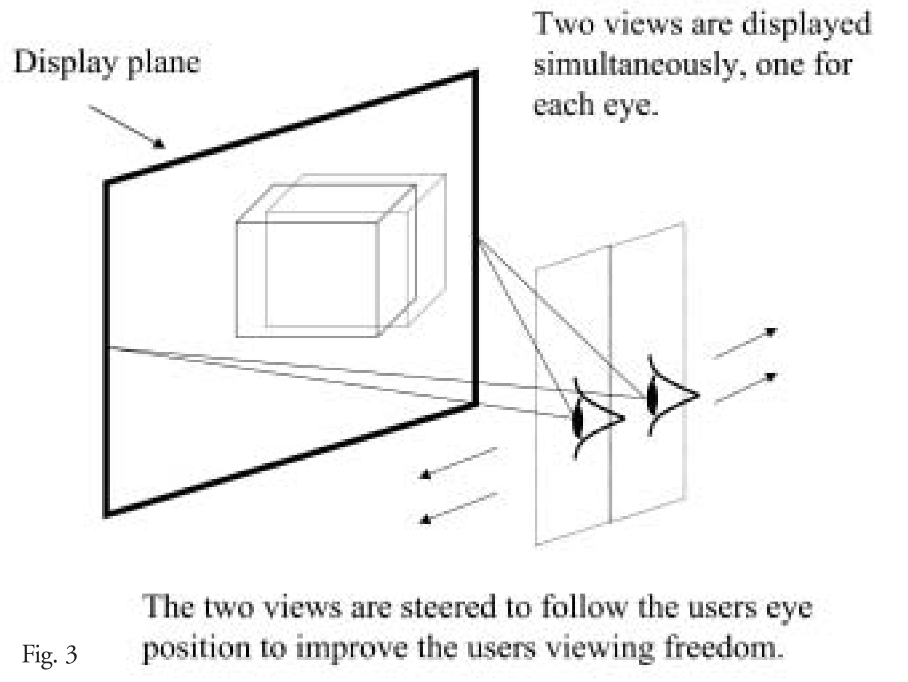

Fig. 3

there is a risk of viewers remembering the eyestrain they felt and not the message in the content.

> *'There are surprisingly few software tools to help and, as a result, you can find that images are not always well produced and may be hard to view comfortably.'*

Challenges

3D displays are becoming more widely available, as stereoscopic projection systems, auto-stereoscopic desktop displays, auto-stereoscopic mobile phones and auto-stereoscopic PDAs are all available or imminently available on the market. The range of devices being sold and/or demonstrated by major multinational companies is increasing yearly. The immediate challenge for potential users is to choose the right display technology for their task.

The electrical interface requirements from computer to 3D display are almost as varied as the range of displays available. This is something users are not used to needing to understand on desktop computer systems. The challenge for manufacturers of 3D display systems is to ensure that this interface becomes transparent to users.

Software tools for creating digital stereoscopic content, and standards for storing and distributing it are beginning to appear. There remain significant challenges here before it will be possible to routinely produce digital stereoscopic images on the desktop. Tools producers and standards bodies need to address these challenges while accounting carefully for human factors issues.

Even as these challenges are successfully addressed, digital content and application producers need to consider the creative and usability challenges within their field. It will not simply be enough to add stereoscopic effects to existing content; new ways of using the stereoscopic depth effect to entertain and inform will need to be developed.

Digital stereoscopic images create great interest and enthusiasm among viewers; they also give very real benefits in many application areas. The challenges above are being addressed by a worldwide community of researchers and manufacturers, and significant investment is being made in creating practical technologies. During February 2005, the Global 3D Consortium of researchers and developers will hold its third annual meeting in Tokyo. The new possibilities of digital stereoscopic imaging might even surprise Sir Charles Wheatstone.

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