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How does the DTI display work?

When viewing the real world, the human visual system uses many different cues to construct an internal three dimensional model of what it is seeing. There are many such cues, including shadowing, perspective, the apparent size of objects, and many others. All of these cues are used in current attempts to simulate 3D on a 2D screen, and these techniques are common in computer games, CAD/CAM design programs and the like. But they are not real depth 3D.

One of the most important cues, and the one that gives you the vivid sensation of depth that you see only when looking at the real world or a 3D movie, and nowhere else, is called *binocular disparity*. That is the term for the fact that the image that your left eye sees and the one that your right eye sees are slightly different from one another; your eyes are looking at the world from two different locations, about 2.5" apart on average. The shapes of the objects seen by each eye are slightly different, and the way they line up with one another are slightly different.

The brain processes the differences in these two slightly different views to provide an accurate representation of the three dimensional shape and position of objects within the scene. This is the real depth 3D that we see in the real world.

All stereoscopic imaging systems work by creating at least two images of each scene, one image of the scene as a person's left eye would see it, and the other as a person's right eye would see it. These two images are called a stereo pair. The imaging system must cause the left eye to see only the left eye image, and the right eye to see only the right eye image.

With the DTI display, this is accomplished with a special illumination pattern and optics behind the LCD screen which make alternate columns of pixels visible to the left and right eyes when you are sitting in front of the display, or in certain areas off to the side.

As illustrated in Figs. 1 and 2, the DTI system displays left and right halves of stereo pairs on alternate columns of pixels on the LCD. The left image appears on the odd numbered columns and the right image appears on the even numbered columns. For example, if an LCD is used that has 1024 columns and 768 rows of pixels, each complete stereoscopic image consists of 512 columns and 768 rows.

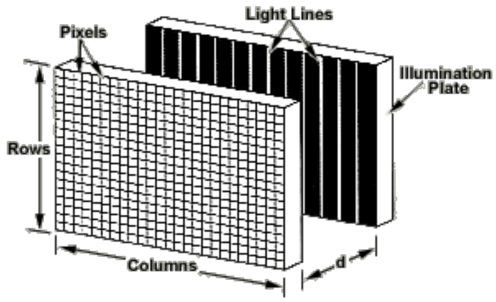

Figure 1

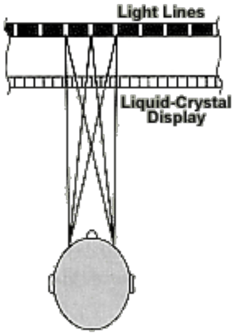

Figure 2

Both halves of a stereo pair are displayed simultaneously and directed to corresponding eyes. This is accomplished with a special illumination plate located behind the LCD. Using light from compact, intense light sources, the illumination plate optically generates a lattice of very thin, very bright, uniformly spaced vertical light lines, in this case 512 of them.

The lines are precisely spaced with respect to the pixel columns of the LCD. Because of the parallax inherent in our binocular vision, the left eye sees all of these lines through the odd columns of the LCD, while the right eye sees them through the even columns. The left eye sees only the left eye portion of the stereo pair, while the right eye sees only the right eye portion. This enables the observer to perceive the image in three dimensions. This arrangement, exclusive to DTI, is called Parallax Illumination.

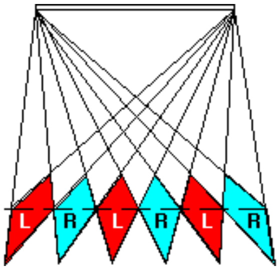

Figure 3

There is a fixed relation between d -- the distance between the LCD and the illumination plate -- and the distance between the observer's face and the LCD screen, the viewing distance. This distance in part determines the dimensions and positions of the "viewing zones" depicted in Fig. 3. These viewing zones are the regions in front of the display where the observer can perceive the left and right eye images. Stereoscopic images can be seen from any position where one's left eye is in a left eye zone and one's right eye is in a right eye zone.

When the halves of the stereo pair are made to correspond to the scene perspective that would naturally be seen by the respective eyes, a vivid illusion of three-dimensionality is created. The objects seem to come out of the screen, giving the impression of an open window through which objects can protrude or retreat into the background. Hence the name Virtual Window.

In addition, the Parallax Illumination system is designed so that it can generate in the same display at a flick of a switch both stereoscopic and non-stereoscopic images, the latter at double the resolution. This ability to instantly switch from 3D to 2D makes the DTI monitor unique in the world. No other 3D flat panel display can provide full resolution 2D images. This allows the DTI display to become the primary desktop display, since it can be used for both 2D and 3D images with the push of a button.

Although DTI 3D displays are designed to be used by one person at a time, this technology does allow several people to view stereo at the same time. Note that the areas where left and right eye views are seen repeat to the left and right of center. One can see 3D from any position where the left eye is in a left eye zone and the right eye is in right eye zone. Additionally, there is little effective vertical restriction. The 3D effect is readily seen whether sitting directly in front of the display or standing behind the person sitting in front of it.

DTI PATENTS ISSUED

DTI has been researching this form of 3D imaging since the mid-1980s and we hold many of the world's major patents on this technology. As of mid-2001 the patents below have been issued. There are a number of other patents due to be issued soon. Our on-going R&D; effort promises to produce many more patentable ideas in the future in the areas of 2D/3D displays, projection displays and high resolution displays.

Patent #4,717,949
Covers the basic technology for the products. A light emitting line pattern fronted by a transmissive display provides bright stereo images the viewer can see without special glasses. Stereo images can be generated from a computer, dual television cameras, sonar or radar. Allows "hologram-like" look around.

Patent #4,829,365
A continuation of Patent #2. Numerous variations on the basic technology are covered. Different illumination patterns and masks are used to:

A. Create a display that is compatible with existing 3D software and the dual television camera input systems of DTI's two major competitors.
B. Broaden the claims of Patent #2 to cover any variation of illumination patterns behind the transmissive displays that create autostereoscopic images.

Patent #5,036,385
The speed of the 3D technology of Patents #2 and #3 is increased. By using faster LCDs in front of different illumination patterns:

A. Images with the full resolution of the LCD, hologram-like look around, and a wide 3D viewing area without position restrictions is established.
B. 2D resolution is increased by a factor of two or more without increasing the number of pixels on the LCD.

Patent #5,040,878
This patent covers specific technology discovered through problem solving associated with building the first 3D monochrome commercial unit including:

A. 3D backlighting system
B. the reflector panel

C. 2D/3D switching

Patent #5,349,379
Covers components developed for the all-electronic head tracking system that allows viewer head movement.

Patent #5,311,220
A variation of Patent #4's basic technology that will allow multiple person head tracking and projected 3D, allowing multiple person viewing without head position restrictions. May have eventual application in home television.

Patent #5,410,345
Covers details of the construction and operation of the illumination systems for use with the 3D technology described in Patent #4.

Patent #5,457,574
Covers a variation on the optics and illumination used in Patents 2, 4 and 7 that allows very high brightness and/or power efficiency to be achieved through concentration of light.

Patent #5,606,455
This is a division of patent #9 ordered by the patent office due to the number of variations described in the original application. It contains claims covering many of those variations.

Patent #5,428,366
Covers a variation on the increased resolution technique of Patent 4 and the illumination system of Patent 8 in order to provide field-sequential-color imaging without image breakup problems associated with previous field-sequential-color techniques.

Patent #5,500,765
Covers a low-cost 2D/3D system for use with laptop and notebook computers.

Patent #5,897,184
Compact light guide system allowing switching between 3D and full resolution 2D illumination.

Patent #6,157,424
Compact 2D/3D system involving 2D/3D panels that can be integrated with the image forming LCD in various configurations.

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