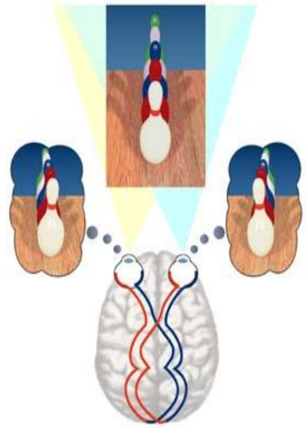
Stereoscopic 3D and iZ3D Perception

3D or Stereo Visions



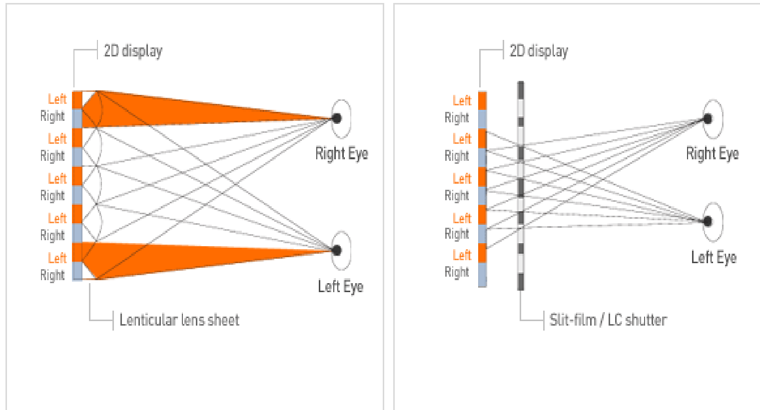
Humans, unlike horses and birds, have two eyes which are located side-by-side in the front of their heads. Because of the eye separation (~6.5 cm) each of the two eyes sees a slightly different image of the same object. The two slightly different images are sent to the brain. As both images arrive simultaneously the brain processes the two images and combines them into one. Because of the slight difference in the two images, depth is unconsciously inferred. Early visual perception studies described vision as a form of unconscious inference: vision is a matter of deriving a probable interpretation for incomplete data. Unconscious inference requires prior assumptions about the world. The unconscious inference hypothesis has recently been revived in so-called Bayesian studies of visual perception. Proponents of this approach consider that the visual system performs some form of Bayesian inference to derive a perception from sensory data. Models based on this idea have been used to describe various visual subsystems, such as the perception of motion or the perception of depth. It is the perception of the depth dimension (3D) that makes stereo vision life-like.

3D History

In June 1838, Sir Charles Wheatstone addressed the Royal Scottish Society of Arts on the phenomena of binocular vision. Wheatstone showed that horizontal disparity (objects at different distances) was an effective depth cue by creating the illusion of depth from flat pictures that differed only in horizontal disparity.

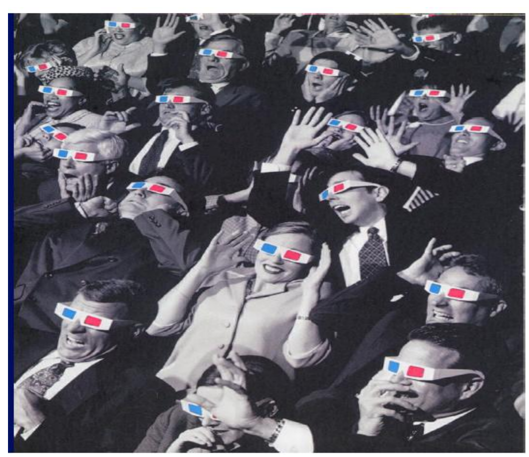
To display his pictures separately to the two eyes, Wheatstone invented the stereoscope. His mirror stereoscopic viewer required that both pictures in the pair be reversed laterally. In describing the equipment he said: "I...propose that it be called a Stereoscope" to indicate its property of representing solid figures. The word "stereo" comes from the Greek word "stereos" which means firm or solid. Wheatstone's actual stereoscope is preserved at the Science Museum in London.

Since that time numerous methods have been developed to display images that closely replicate human stereoscopic visual perception functions. However, all of the methods and equipment are compromises that either require vision aids or restrict the viewer's freedom of movement. Additionally, some methods, such as time sequential left/right eye addressing (active glasses), will negatively affect viewer's vision systems and cause discomfort to various degrees. Because the left and right eye shutters in the glasses alternately open and close to assure each eye sees only the appropriate image, the brain must work overtime to compile these sequential images into one image that ultimately shows the 3D effect. This extra demand on the brain leads to nausea and headaches. Extreme cases, like photosensitive epilepsy (PSE) may cause lasting vision defects and may even require hospitalization (Pokemon Incident). Nevertheless, for critical data acquisition and tasks that can not be carried out otherwise, such as laparoscopic surgery or complex molecular modeling, doctors, engineers and scientist will resort to time sequential 3D viewing. Because 3D effects with such professional equipment can be compelling, users can minimize the associated discomfort by using the equipment for short intervals and by limiting the overall viewing time.



[Principle of glassless 3D display]

In the entertainment industry, 3D movies were released as early as 1915. Although during the past century Stereo Viewing Equipment and content was developed for entertainment, these efforts all fell short of expectations in image quality and viewing comfort. During the 3D boom that began in the 1950s over 5,000 theaters in the US were equipped to show 3D movies, but the fad was short-lived as 3D content production figures show: 1952—1; 1953—27; 1954—16; 1955—1. In addition there were 3D movies produced in Japan, Britain, Mexico, Germany and Hong Kong.

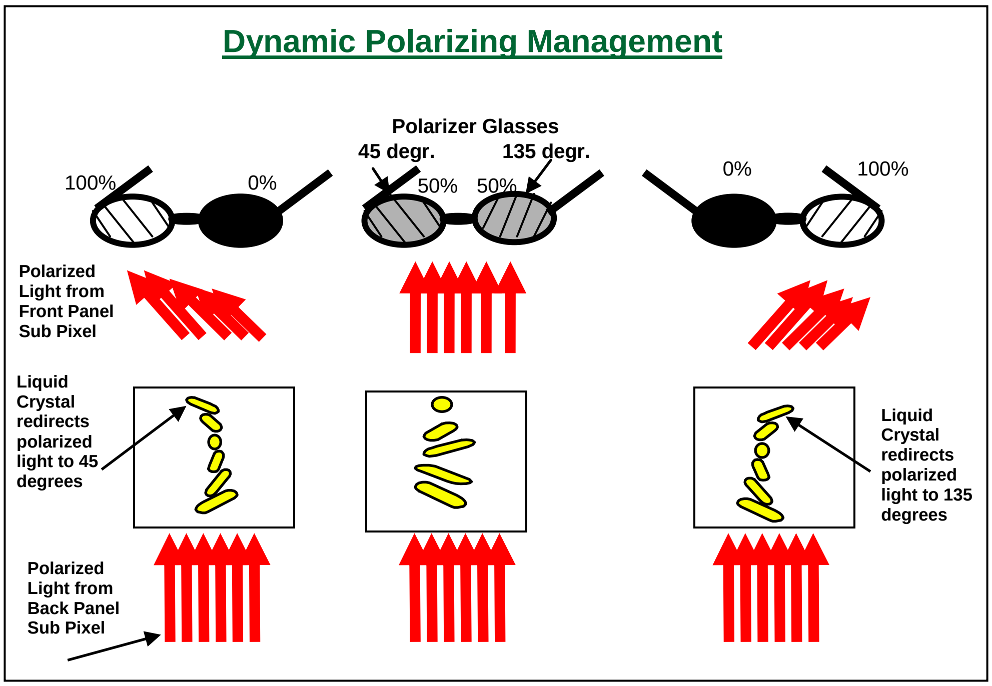


However, with the advances in camera technology and computer graphics content creation, the movie industry is focusing on 3D once more. With IMAX being probably the leader with its 3D cameras that incorporate two identical lenses which are precisely spaced to match the distance between human eyes. This interocular distance allows each lens to "see" both left and right-eye views exactly as your eyes would see them. This helps to facilitate realistic 3D images once projected. To enable the 3D effect, polarized glasses worn by the audience are precisely matched with the polarizing filters of the projector's twin lenses. While the projector lenses superimpose separate left and right eye views on the screen, the polarizer glasses make sure that each eye sees the appropriate image, allowing the brain to create a single 3D image. Actually polarizer glasses for 3D viewing are much like polarized Sunglasses everyone wears to protect their eyes from bright light and glare. With one exception, for 3D viewing the polarization angels of the glasses need to match the polarization of the image.

IMAX movies and Real D screenings, such as Polar Express and Monster House, received great response from the theater going public, which is a validation of polarization based 3D as being comfortable for long periods of 3D viewing with polarized glasses. Using polarizer based 3D visualization technology, similar to the two image projection technology, iZ3D LLC developed 17” and 22”W iZ3D monitors.

iZ3D Visualization

Similar to IMAX and Real D, iZ3D superimposes two images. Except iZ3D images are created on two precisely stacked TFT LCDs (thin film transistor liquid crystal displays). Again similar to 3D movies, iZ3D technology is based on polarized light to create images for left and right eye viewing. But unlike film and filters with fixed polarizer angles for projectors, iZ3D controls left and right eye image creation by dynamically changing the polarity of each picture element (pixel). Left eye and right eye images are addressed and controlled simultaneously. With the software based iZ3D image control algorithm, the back TFT LCD is controlling the intensity of the transmitted light and the front TFT LCD controls the polarization angle of the transmitted light. In reality iZ3D updates the images 60 times per second. However, the change to the required polarization angle is performed sub-pixel by sub-pixel. That means that for 1680 x 1050 resolution, up to 600 million sub-pixels are reoriented every second for each image frame change. The polarizer films on the back LCD panel determine the polarizer axis of the light as it enters the front panel. To dynamically control the light transmission of the back panel and the front panel, iZ3D takes advantage of liquid crystal’s inherent polarizing characteristics. Because of liquid crystal’s inherent polarizing characteristics, the liquid crystal of the front panel redirects the entering polarized light, according to degree of the liquid crystal twist. To control the liquid crystal twist, an electrical field is applied. Varying the electric field, sub-pixel by sub-pixel, results in polarization angle changes for each sub-pixel. The specific liquid crystal material in iZ3Ds will respond to electrical field changes with changes in the polarization angle anywhere between 45 degrees and 135 degrees. Since the light from the front panel is polarized, but the front of the display is without polarizer film, the polarized light from the front panel can only be seen with linear polarizer glasses that have 45 degrees axis for the left eye and 135 degrees axis for the right eye. Polarized light intensity at angles between 45 degrees and 135 degrees is proportionally shared by both eyes. For example, at 45 degrees, the left eye will see 100% of the light and the right eye will see 0%. Since left and right images are seen at the same time, at 90 degrees both eyes will see the same image with the same intensity. Therefore, at 112 degrees 25% light is directed to the left eye and 75% is directed to the right eye. This method of simultaneously addressing, controlling and displaying left and right eye images creates flicker-free images for comfortable prolonged 3D viewing enjoyment.



Displaying iZ3D Images

To display an image on the iZ3D monitor in 3D, the following is required:

Hardware

- Windows PC, including Window XP and Vista, both x32 and x64 versions
- ATi, including CrossFire X, nVIDIA or other DirectX compatible graphics card with two outputs
- iZ3D Monitor

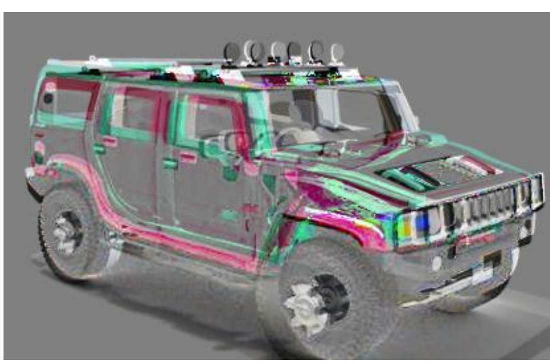
Software

- iZ3D Stereo Driver
- Content with depth information

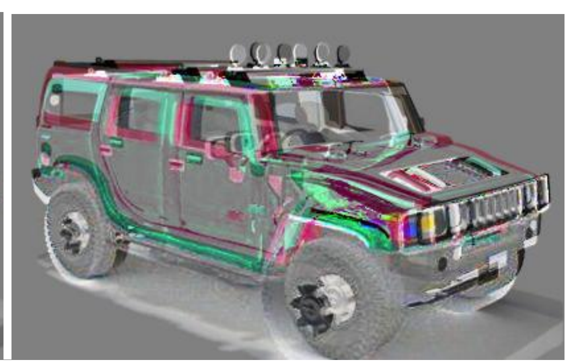
iZ3D Image Creation Principle

Left and Right image information streams to the Graphics card are converted by the iZ3D algorithm into Back and Front information. The Back and Front information is transmitted to Back and Front panels of the iZ3D monitor. The Back panel information is then combined with the information on the Front that is a mix of depth cues intended for the left eye, when polarized to 45 degreed, and for the right eye when polarized to 135 degrees. The superimposed images, which are different for the left eye and the right eye, same as observed in nature, are sent to the brain simultaneously, where the images are combined into one 3D image.

2D Image on Back TFT LCD



Front TFT LCD – Left Eye View



Front TFT LCD – Right Eye View

3D image without polarizer glasses shows parallax outlines

3D image viewed with polarizer glasses

Stereo Drivers

In electronic games with 3D graphics the graphics data is sent through Direct X to the Video Card.

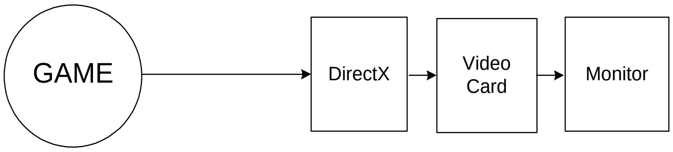


Figure 1. Data flow in 3D Games

The stereo driver intercepts the data stream prior to the video card and adds stereo camera information and the iZ3D algorithm. This information enters the Video card and it is rendered into left and right images. Still in the Video card, the iZ3D algorithm transforms the left and right image data into back and front images. With this process all games that are Direct X 8 and 9 based can be played on iZ3D monitors in 3D.

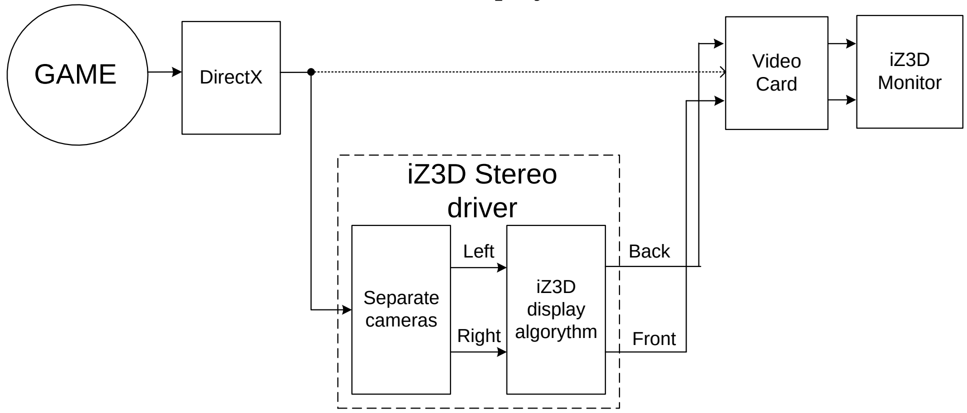


Figure 2. Data flow with iZ3D Stereo Drivers

In iZ3D monitors the 3D image characteristics are user adjustable. The adjustments let the user select optimum conditions for specific viewing preferences, which are primarily related to convergence, parallax and image plane. Adjustments will result in image plane changes for out of screen and into screen position, and in parallax adjustment for scene depth and viewing comfort optimization. For user's convenience, there is an optional auto stereo adjust feature, that adjusts stereo settings dynamically, based on the present scene configuration, for the best visual comfort.

Presently, because of rapidly advancing technology and market conditions, 3D in the entertainment market is receiving renewed attention. Although 3D movies are shown in more than 700 theaters in the US, compelling 3D content for home entertainment is prevalent only in the electronic gaming market. Electronic games is the largest and only cohesive addressable market segment. With its annual hardware and content revenues of over $100 billion, and hundreds of games designed in 3D, this market is ready for 3D monitors. Playing games in 3D is a new dimension that makes players feel part of the game. The rapid growth of the publics interest in 3D is underlined by James Cameron recently statement:"3D display will become a must for video and computer games" and by Jeff Katzenberg's prediction that "moviegoers will some day own their own glasses for 3-D viewing much like they own sunglasses today".

With the promise of compelling content, 3D monitors are becoming consumer electronics products which pave the way for 3D to enter the home, not only for game-playing, but also for TV entertainment.

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Information, excerpts and picture sources:

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