Advanced Topics in Virtual Reality

3D / Stereoscopic Display Methods

http://tinyurl.com/nyd8fpq

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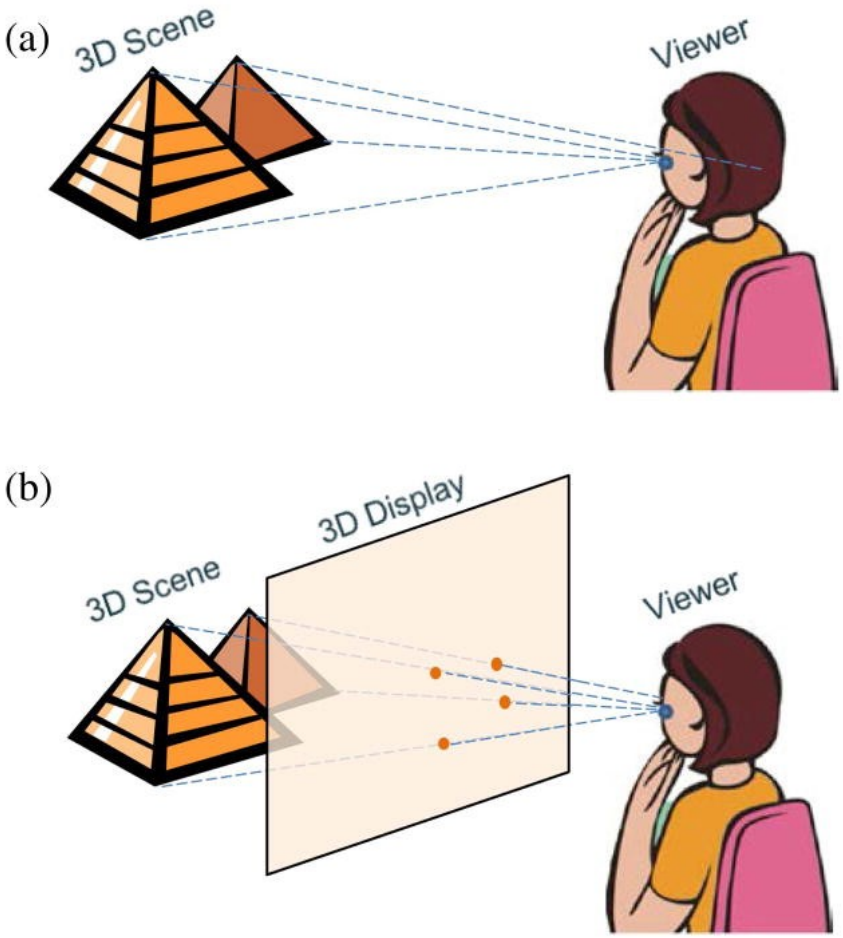
The “Perfect” 3D Display



Geng J. Three-dimensional display technologies. Advances in optics and photonics. 2013;5(4):456-535. doi:10.1364/AOP.5.000456.

Physical Depth Cues

1. **Accommodation**
   is the measurement of muscle tension used to adjust the focal length of eyes.

2. **Convergence**
   is a measurement of the angular difference between the viewing directions of a viewer's two eyes

3. **Motion parallax**
   offers depth cues by comparing the relative motion of different elements in a 3D scene.

4. **Binocular disparity** (stereo)
   refers to differences in images acquired by the left eye and the right eye.

Psychological Depth Cues

1. **Linear perspective**
   is the appearance of relative distance among 3D objects
2. **Occlusion**
   is the invisible parts of objects behind an opaque object.
3. **Shading & Shadows**
   of objects and cast by one object onto another gives strong 3D spatial-relationship clues.
4. **Texture**
   can be used to infer the 3D shape of the object as well as its distance from the viewer.
5. **Prior knowledge**
   of familiar sizes and the shapes of common structures

Plenoptic Function (≈Lightfield)

$$P(x, y, z, \theta, \varphi, \lambda, t)$$

(x, y, z)	position in space
(θ, φ)	direction of light
λ	wavelength
t	time

Classification of Stereo Technology

Separation of Left/Right image by

- Space (multiview: two displays, autostereoscopy)
- Color (red/green, etc.)
- Time (left after right image, „active“ stereo)
- Plane of Polarization (linear polarized)
- Rotation of Polarization (circular polarized)
- Spectrum (Infitec™)

Multiview 3D Displays

previous chapter:

- HMD
- parallax barrier
- lenticular lenses
- “Lightfield” display/HMD

Passive Stereo

Means stereo de-multiplexed by „passive“ glasses, without electronics:

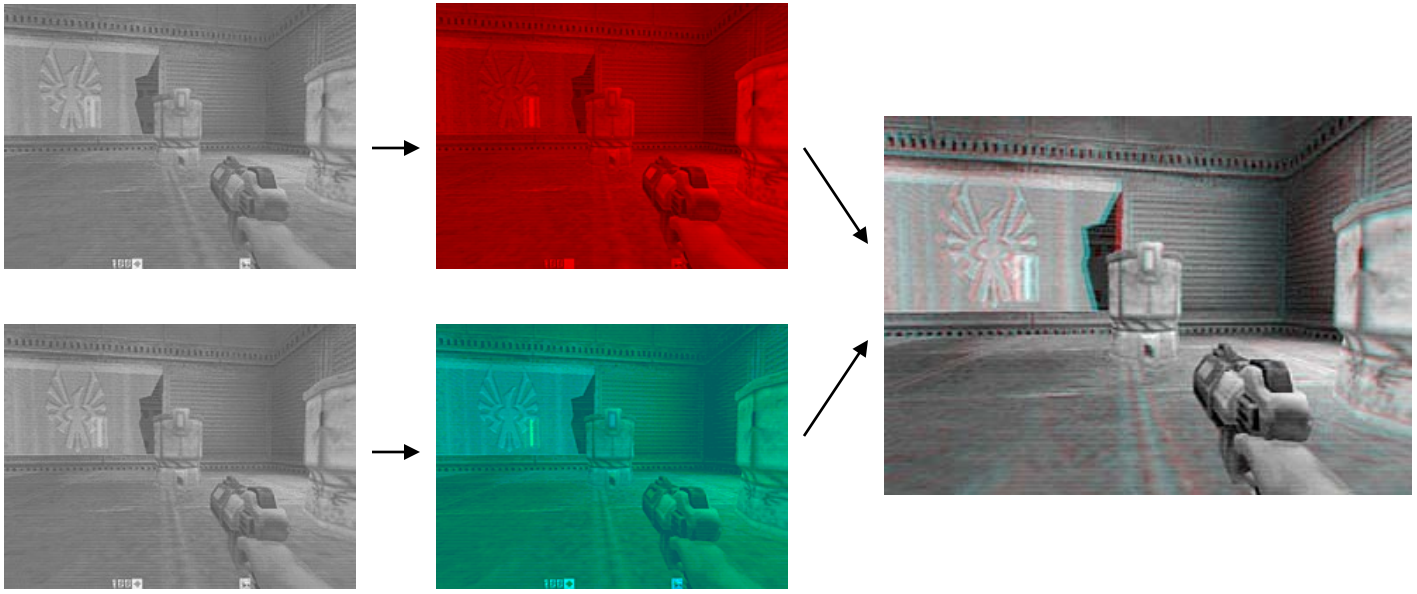
- Color (red/green, etc.)
- Plane of Polarization (linear polarized)
- Rotation of Polarization (circular polarized)
- Spectrum (Infitec™)

Anaglyph Stereo

Multiplexing by using one color for the left eye image and another for the right:

left

right

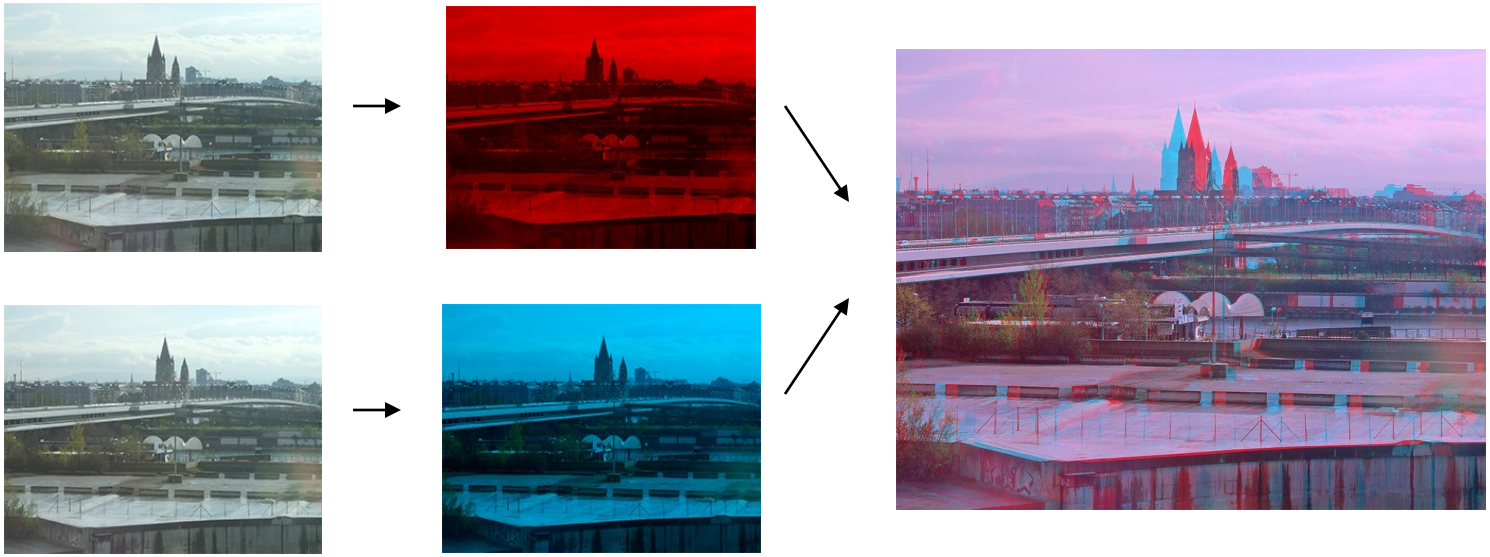


Anaglyph Stereo

Combine color images by replacing the red channel of the right-eye image with the red channel of the left-eye image.

left

right



Anaglyph Stereo

Anaglyph Stereo

Advantages:

- fast
- inexpensive
- works on all color media (print, TV, etc.)
- works good on back-projection

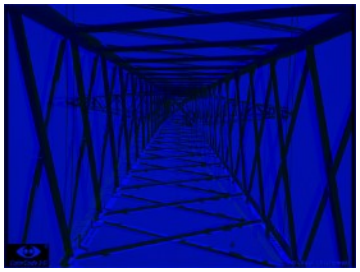
Disadvantages:

- mediocre color reproduction

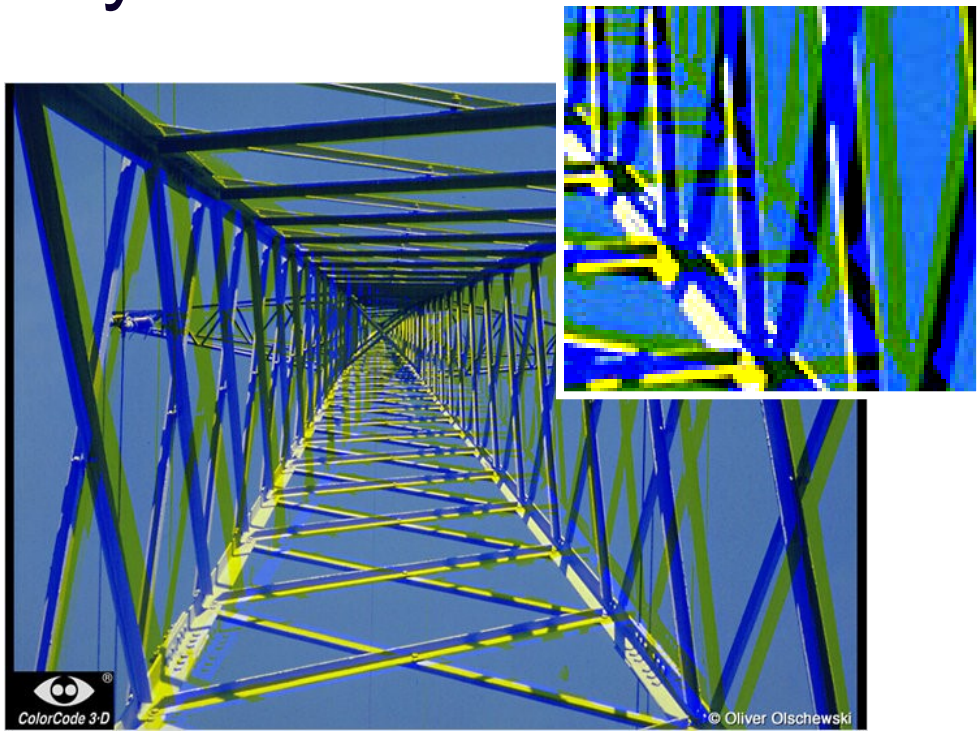
ColorCode 3-D

Multiplexing by „splitting depth and color“ between left & right eye:

left



right



ColorCode 3-D

Advantages:

- fast (use a shader)
- inexpensive
- works on all color media
- works good on back-projection
- displays full color (sort of)

Disadvantages:

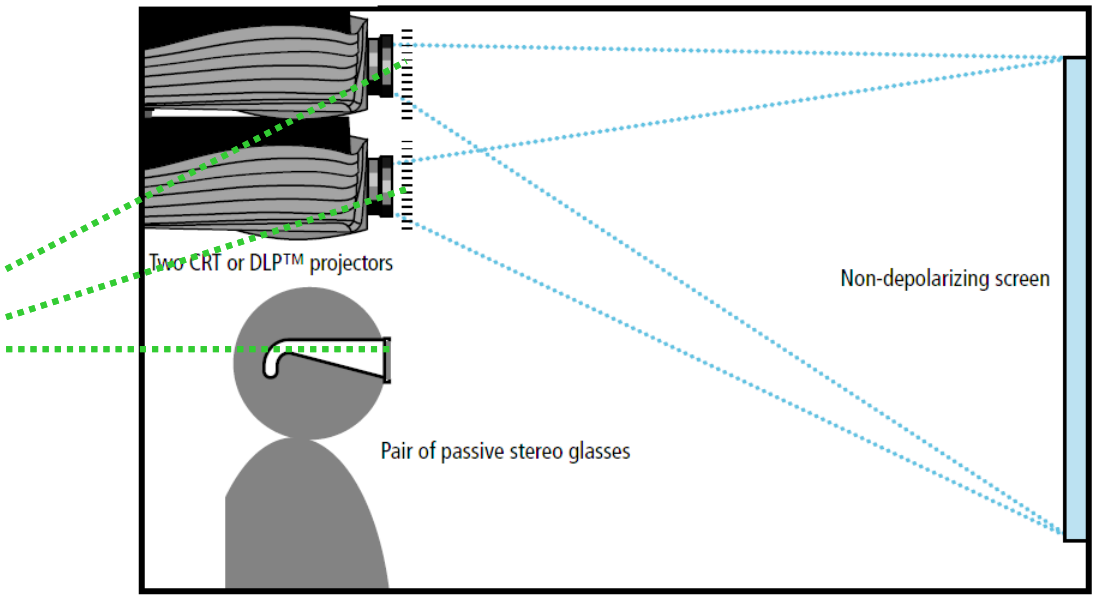
- your brain melts (eyestrain, blue filter very dark)

Polarization Stereo

Multiplexing by manipulating the direction of oscillation of the projected light.

Using filters in front of the projector(s) and users eyes, and a special screen:

polarizing filter



Polarization Stereo

Quality depends on:

filters:

- how much “correct” light is transmitted (R→R, L→L)
- how much “incorrect” light is transmitted (L→R, R→L)

screen:

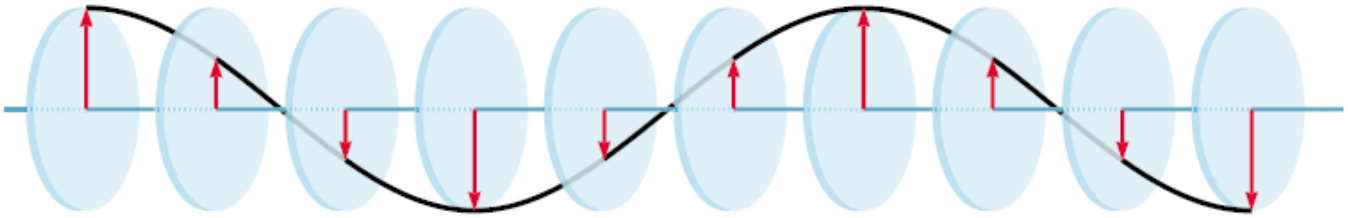
- how much polarization is destroyed?
  (back-projection screens are worse, except for specially designed, hard screens)

Polarization Types

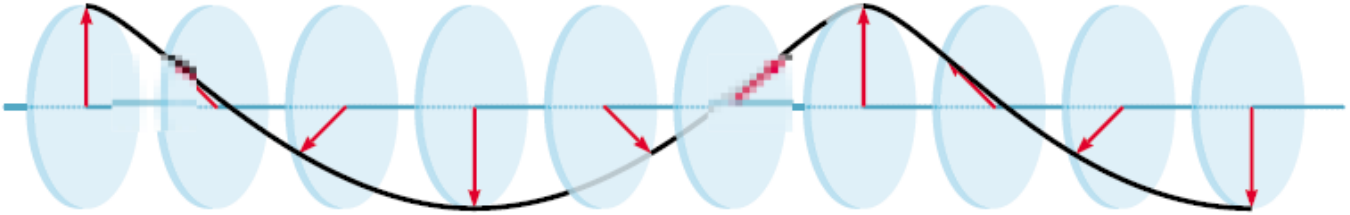
Normal light oscillates in many directions

Linear polarized light oscillates only in one plane

linear



circular

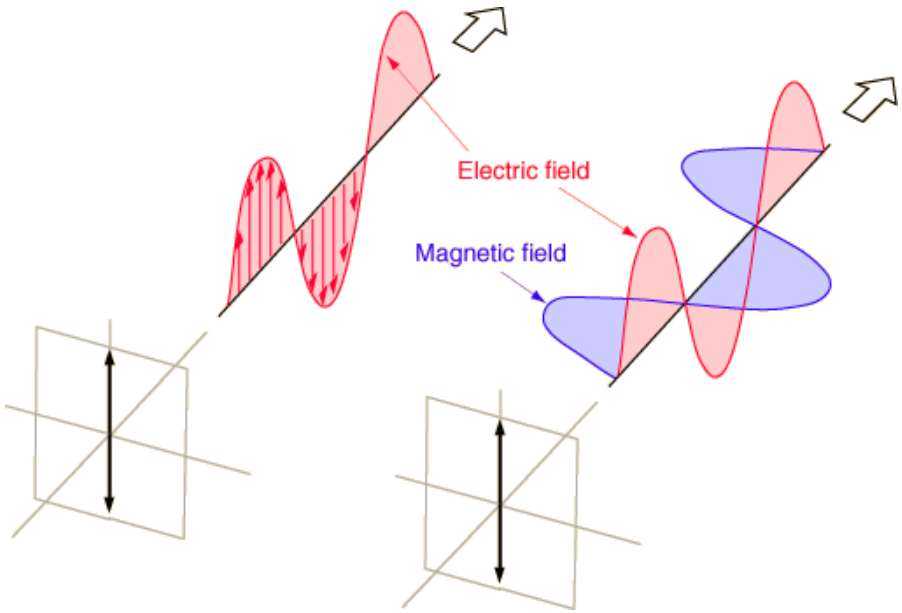


Circular polarized light oscillates only in one rotating direction

Polarization Types

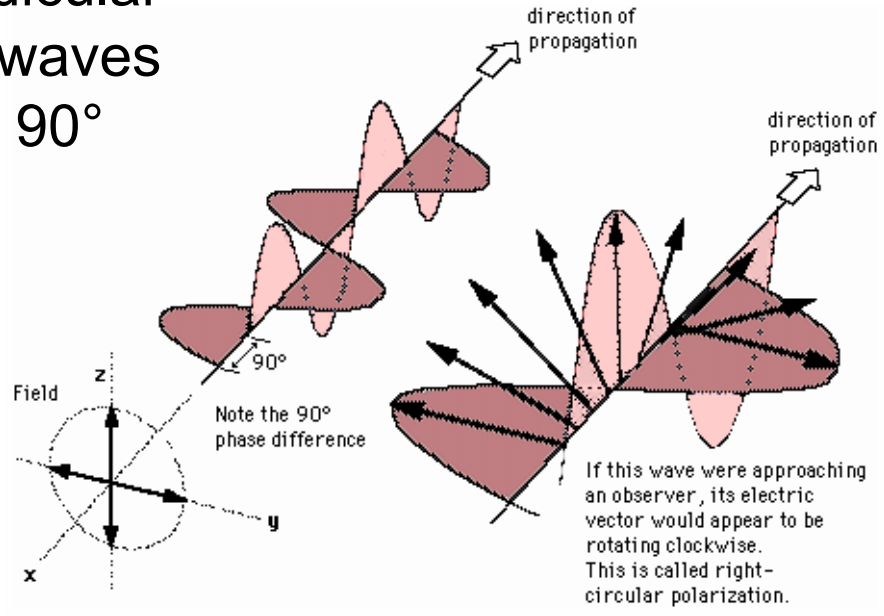
Normal light oscillates in many directions

Linear polarized light oscillates only in one plane



Polarization Types

Circularly polarized light consists of two perpendicular electromagnetic plane waves of equal amplitude and 90° difference in phase.



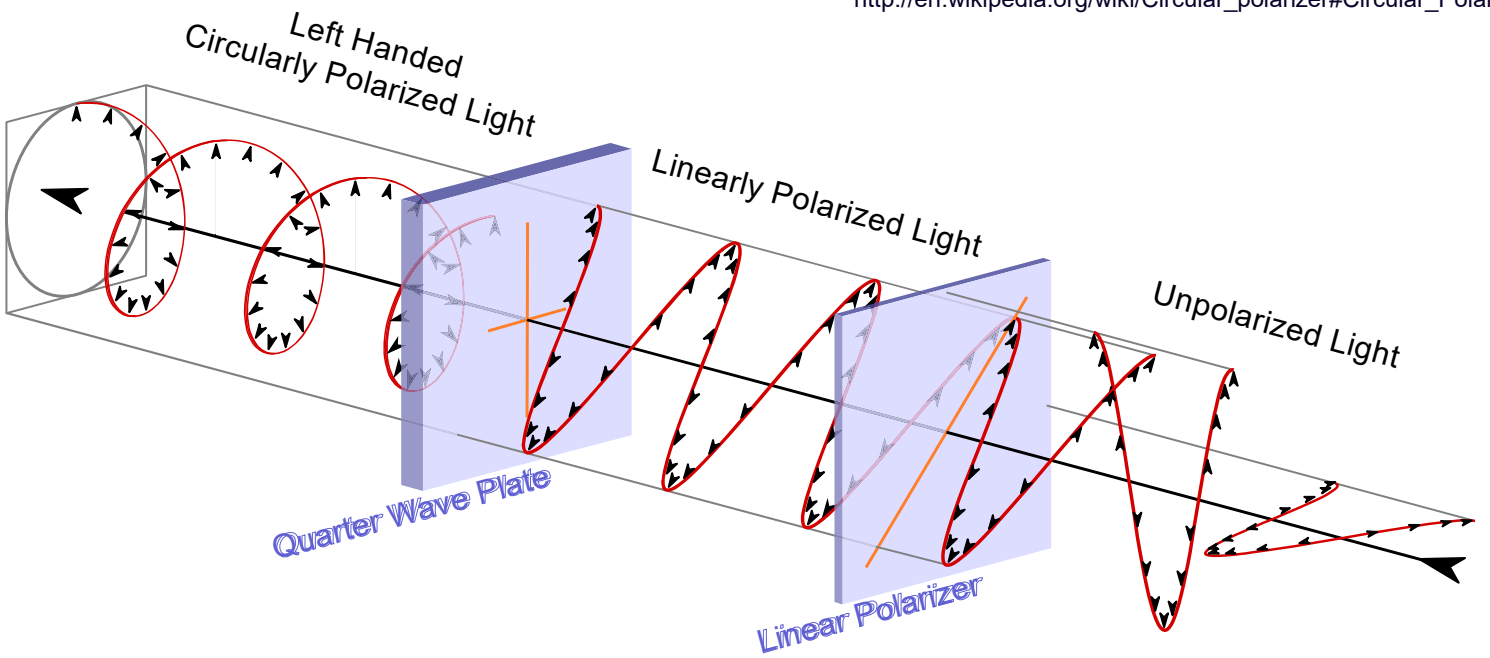
The oszillation direction of circular polarized light rotates

Achieving Circular Polarization

A quarter-wave plate divides linearly polarized light into two components polarized normally to each other and 90° out of phase.

This produces circularly polarized light.

http://en.wikipedia.org/wiki/Circular_polarizer#Circular_Polarizers



Polarization Types

linear polarization:

- orientation dependent
- works with all colors

circular polarization

- works in any orientation of the users head
- color dependent (phase shift filter)
- costs more

Infitec™ Stereo

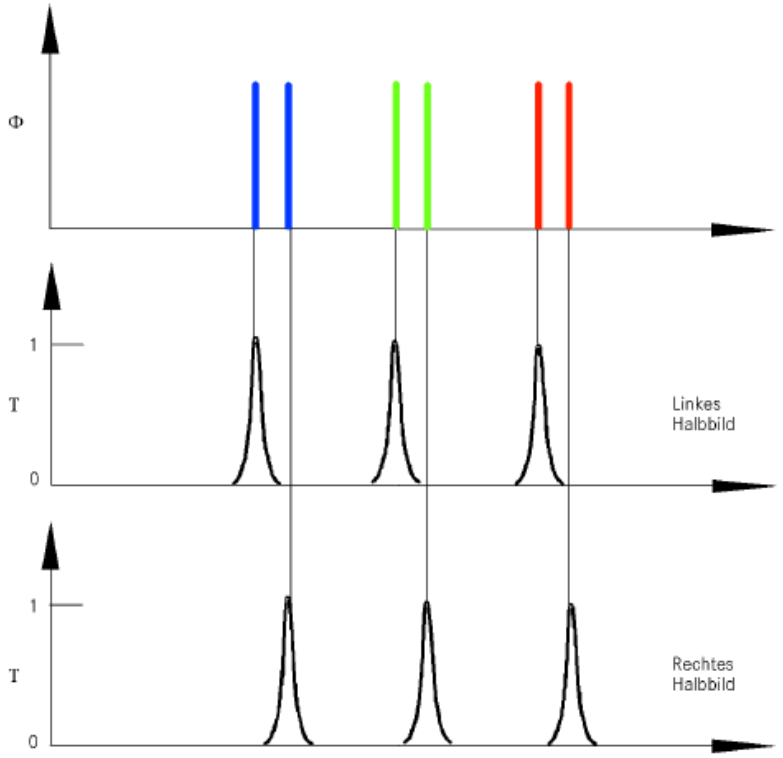
Spectrum Multiplex:

Advantages:

- orientation independent
- screen independent
- high(er) contrast even in daylight

Disadvantages:

- color distortion
- crosstalk



Infitec™ Stereo

uncalibrated

calibrated

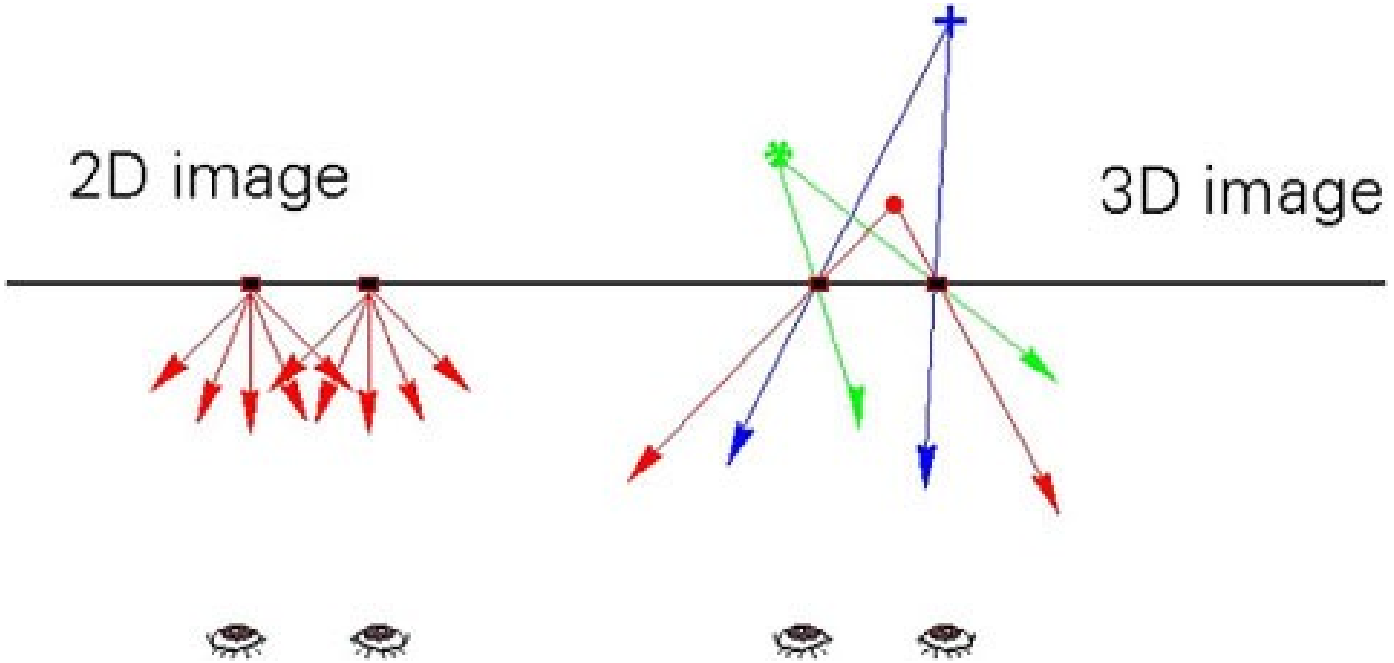
Holographic Projection

Holographic Backprojection by Holografika Ltd. (www.holografika.com)

- No glasses needed, the 3D image can be seen with unassisted naked eye
- Viewers can walk around the screen in a wide field of view seeing the objects and shadows moving continuously as in the normal perspective. It is even possible to look behind the objects, hidden details appear, while others disappear (motion parallax)
- Unlimited number of viewers can see simultaneously the same 3D scene on the screen, with the possibility of seeing different details
- Objects appear behind or even in front of the screen like on holograms
- No positioning or head tracking applied
- Spatial points are addressed individually

Holographic Projection

pixels on screen send different light in different direction, thereby simulating light emanating from points in space:



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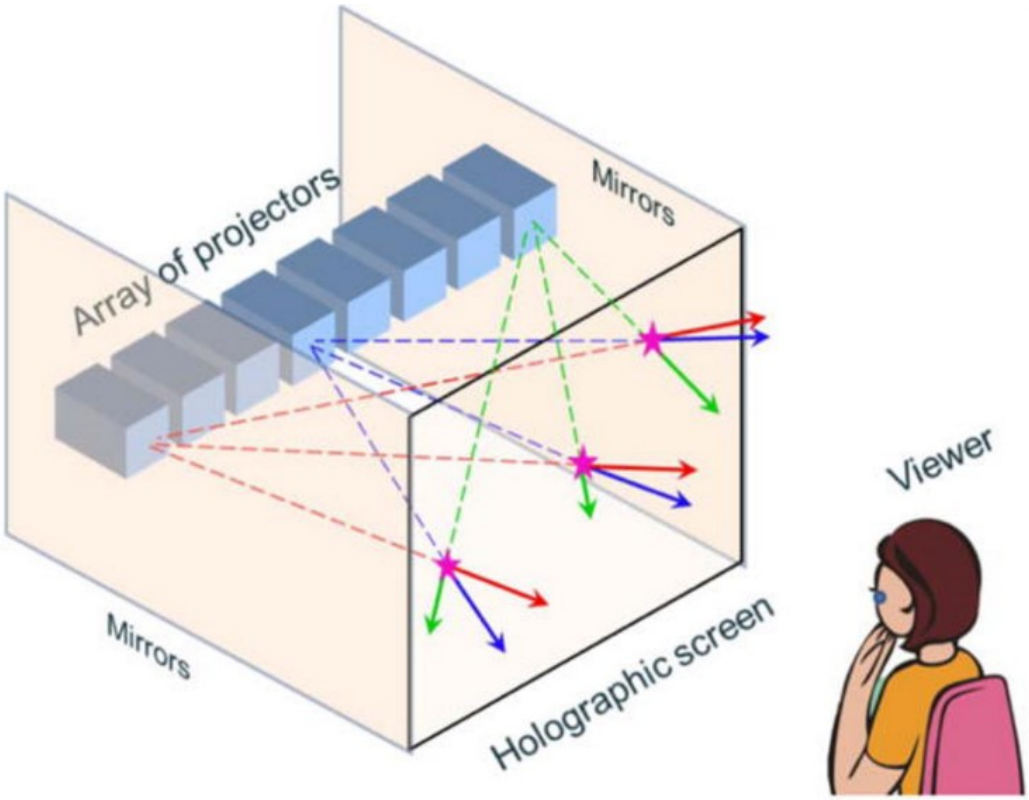

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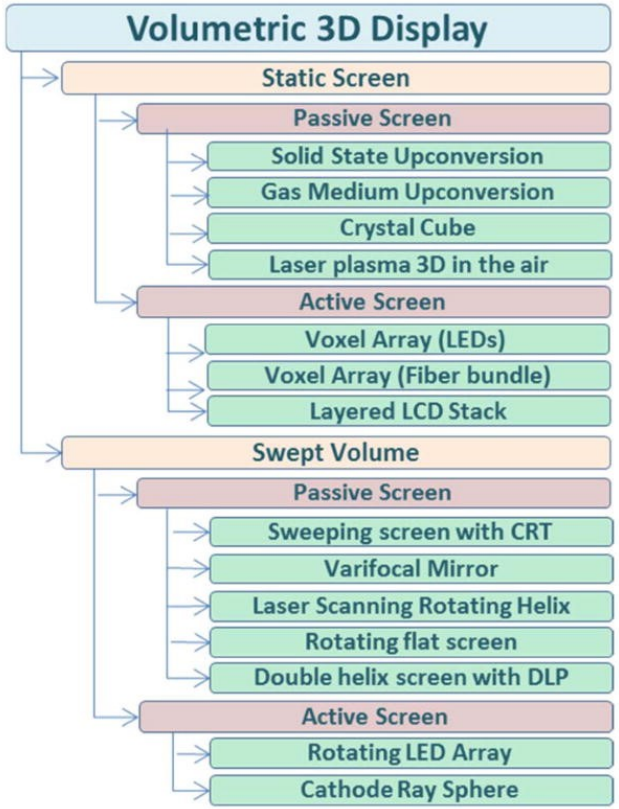
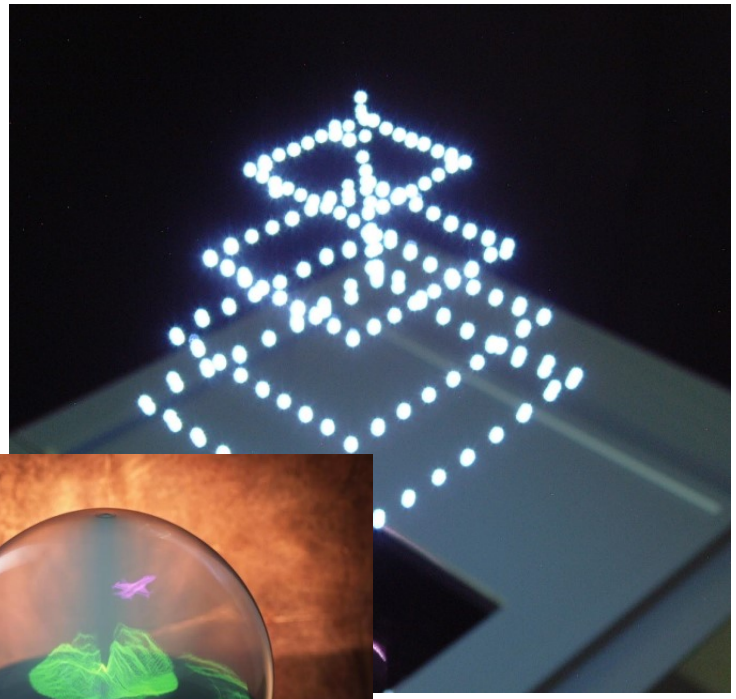
Holographic Projection

pixels on screen send different light in different direction, thereby simulating light emanating from points in space:

Volumetric Display

See previous chapter:





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Next: Tracking Methods