

CSE 190: Virtual Reality Technologies

LECTURE #5: DISPLAYING 3D IMAGES

Upcoming Deadlines

Sunday April 18: Project 1 due

Monday April 19: Discussion Project 2

Sunday April 25: Project 1 late deadline

Monday April 26: Discussion Project 2

Sunday May 2: Project 2 due

Announcements

Immersive Visualization Center Kick-Off Event

- Today at 4:30pm on Zoom
- Register at https://ucsd.zoom.us/webinar/register/WN_cKLZVF9-S4-oBrdN_6ETyg

Oculus Gaming Showcase

- April 21, 3pm

Vivecon

- May 11-12

App Presentations

Patrick Pajarillaga

- Electronauts

Stereo Imaging: Concept

General concept: each eye sees a slightly different image

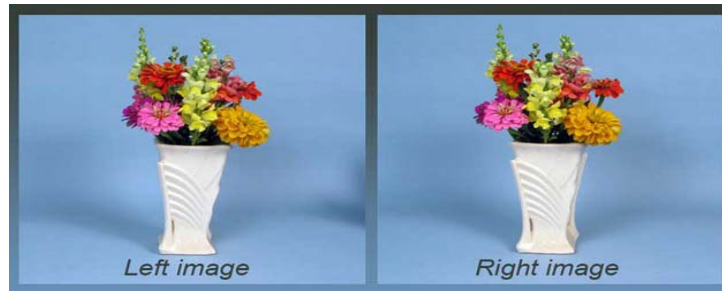
Example: Viewmaster

- Slide reels with 7 image pairs

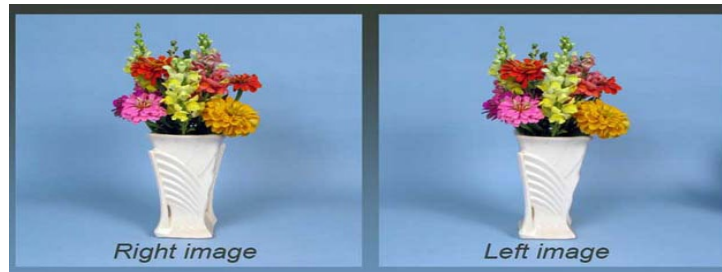


Stereo Imaging: Side-by-Side

Stereo can be seen by fusing images: converge eyes in front or behind the actual image plane



Eyes converge behind image plane

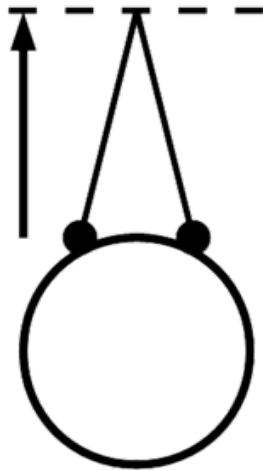


Eyes converge in front of image plane

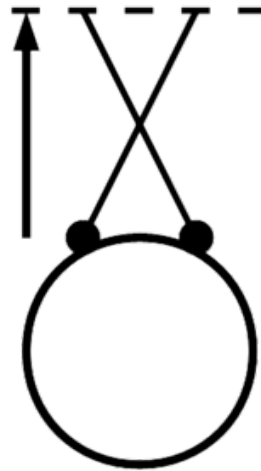
Single Image Stereogram (SIS)

No glasses required

Converge eyes on point in front of or behind the screen.

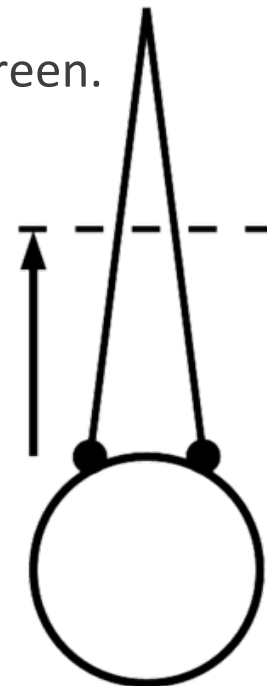


Aligned vergence and
accommodation
(normal viewing)



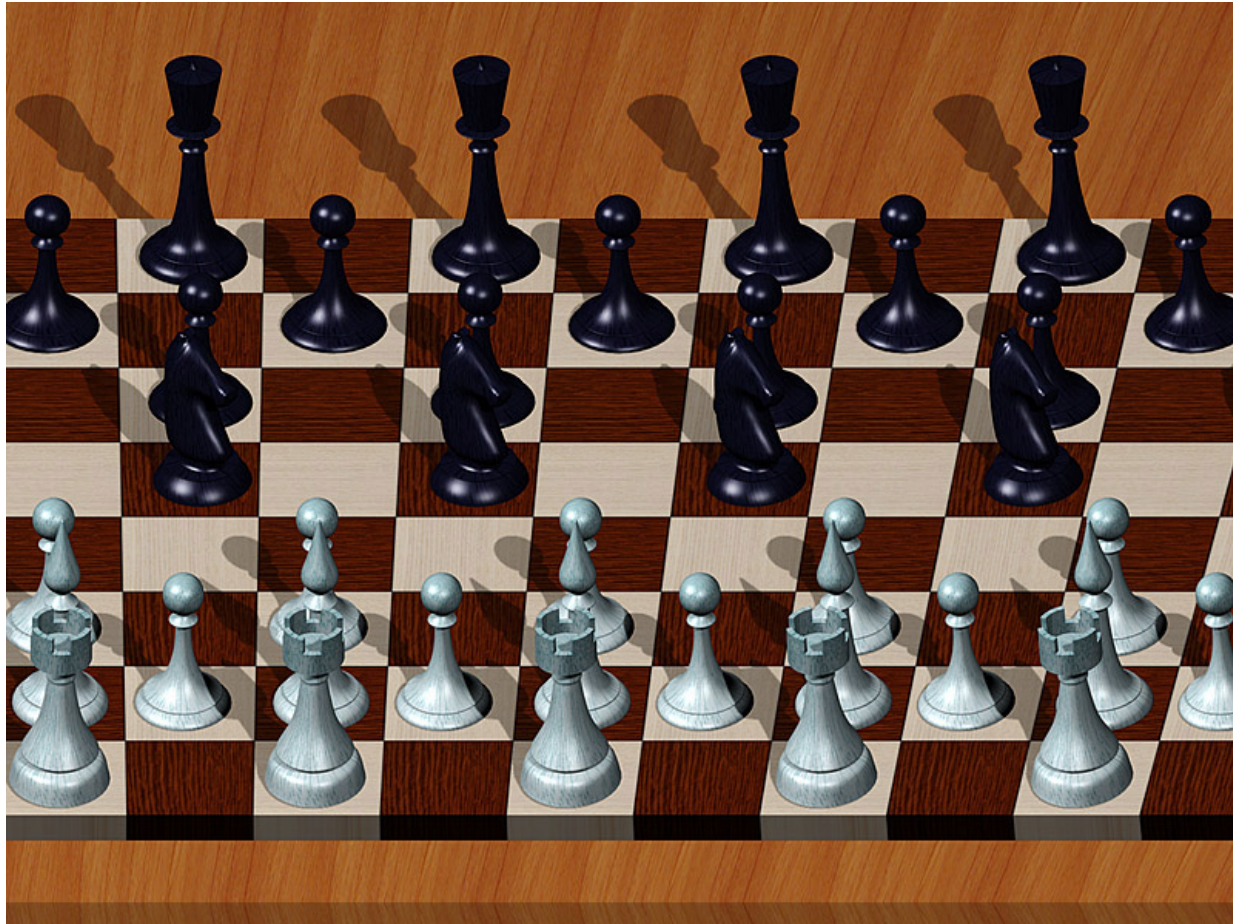
Cross-eyed
vergence.

Arrow: accommodation



Wall-eyed
convergence

SIS: Chessboard



SIS: Shark



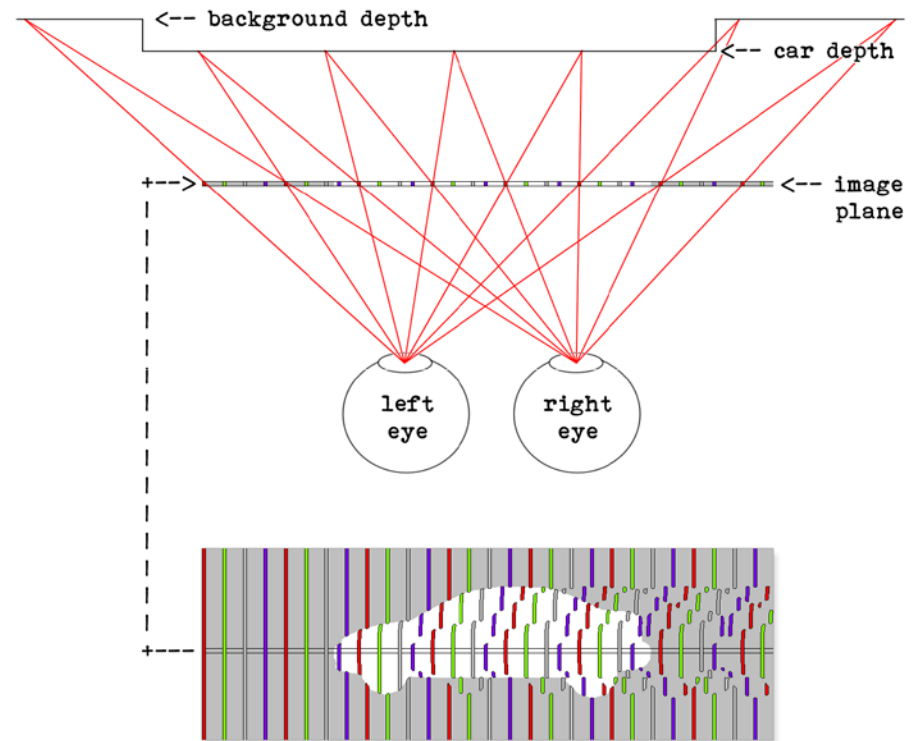


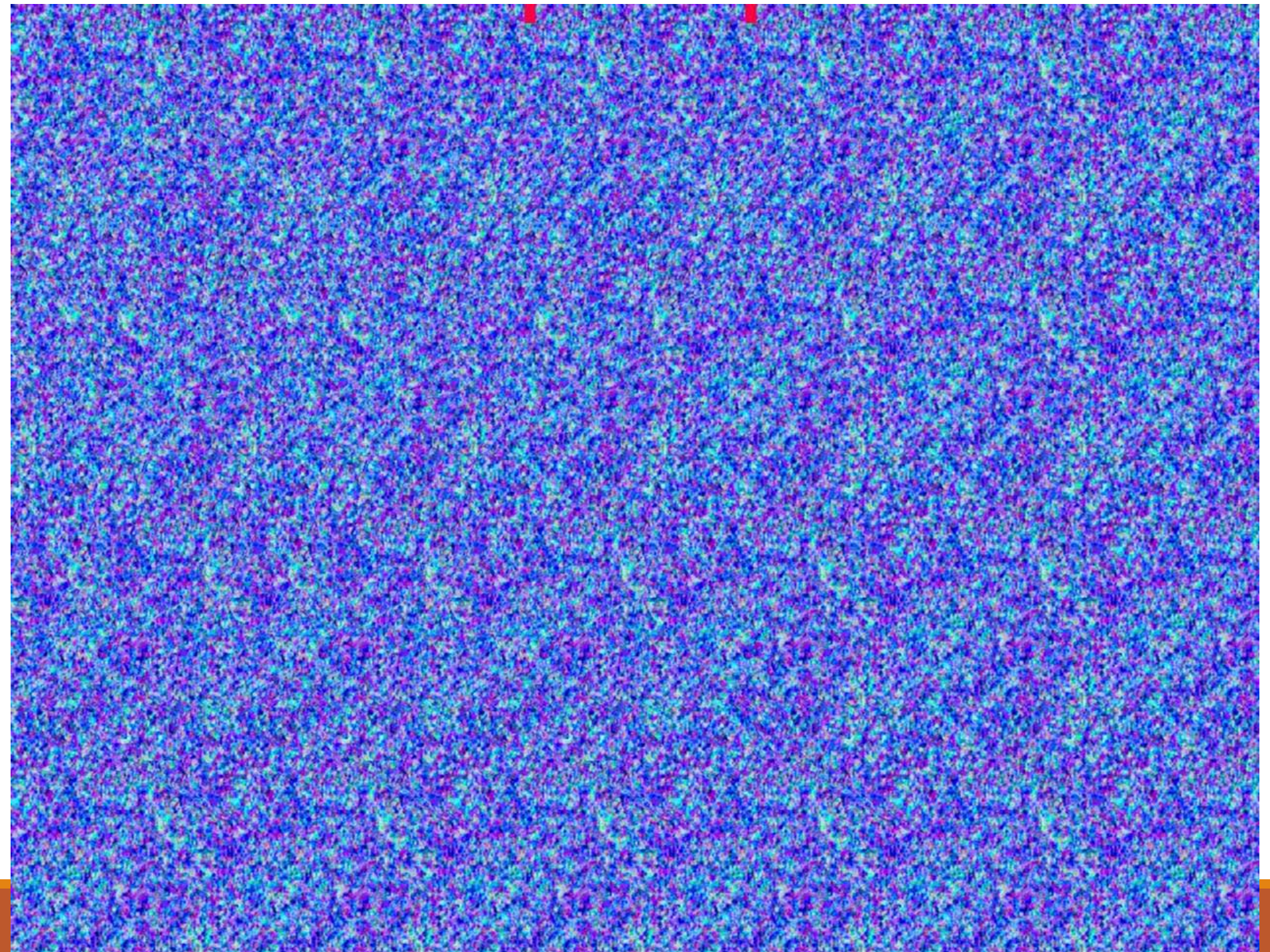
SIRDS: Single Image Random Dot Stereogram

A SIRDS encodes a 3D scene into an image in such a way that both eyes look at slightly distorted copies of the same (noisy) pattern.

The distortion of these copies is specifically crafted to encode the depth of each pixel in a rendered virtual 3D scene.

SIRDS use random dots instead of regular patterns to hide artefacts that could distract the viewer from the illusion.





Autostereoscopic Displays

Light sent separately to each eye from a monitor

No headgear required

Can be head-tracked (dynamic) or non-tracked (static, head assumed in sweet spot)

Approaches:

- lenticular screen
- barrier screen



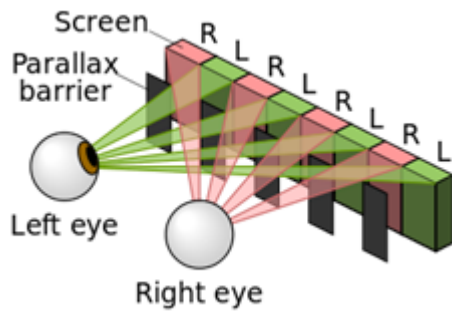
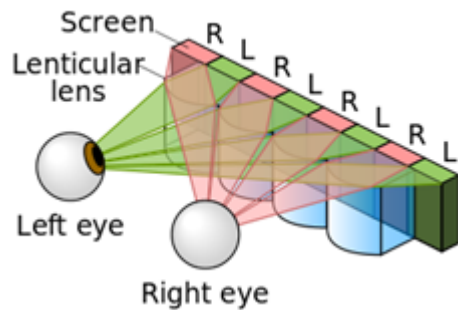
SeeReal display



Nintendo 3DS

Autostereo

Lenticular screen



Parallax barrier

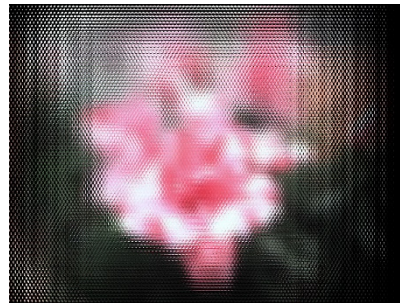
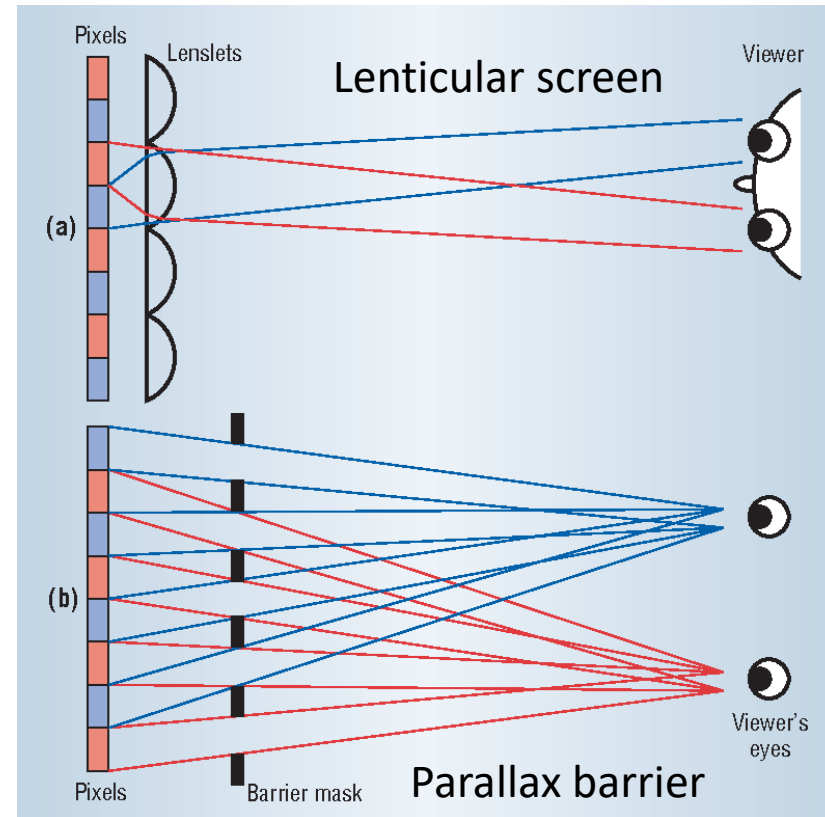


Image without autostereo filter



Stereo with 3D Glasses

Two options:

- Passive stereo: unpowered glasses with optical filters
- Active stereo: powered glasses with LCD shutters



Without polarised lens

With polarised lens

Polarized sunglasses



Active LCD 3D Shutterglasses

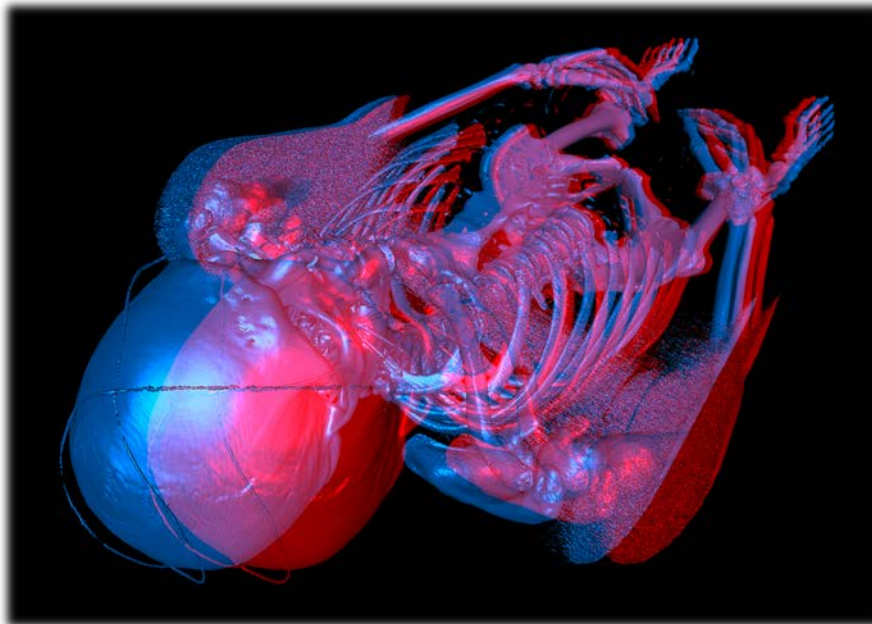
Passive Stereo in Anaglyph 3D

Requires anaglyph red/blue or red/green glasses

- Available in cardboard (~\$0.50) or plastic (~\$5)

Color is diminished (but not entirely lost)

Example below: view with which of the glasses on right?

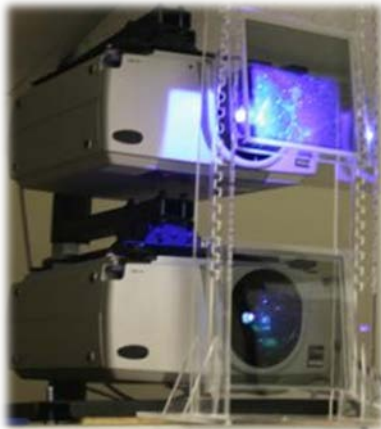


Passive Stereo with Polarized Light

Two options:

- Linear polarization
- Circular polarization: creates circularly polarized light by adding a quarter-wave plate after a linear polarizer

Polarizing glasses are inexpensive (~\$2-10)



Stereo projectors



Polarizing glasses



Passive Stereo Monitors

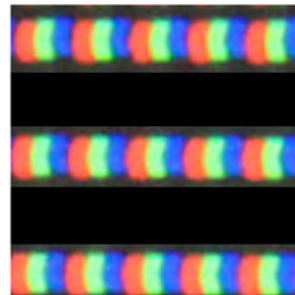
Filter on monitor polarizes
alternating pixel rows
clockwise/counter-clockwise

Best view point is on-axis

Off-axis viewers see ghosting

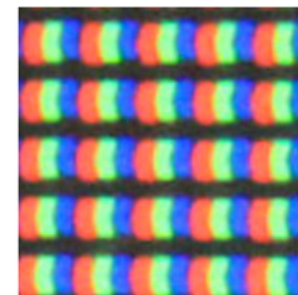
*Looking Closer at How Passive 3DTVs Work ...
Magnified views of 3DTV screen and typical monitor, at same scale*

Vizio E3D320VX 3DTV
32" diagonal
1920 x 1080



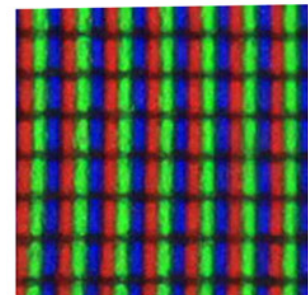
.728 mm / row
(3D mode)

Each eye sees 1/2 of the rows



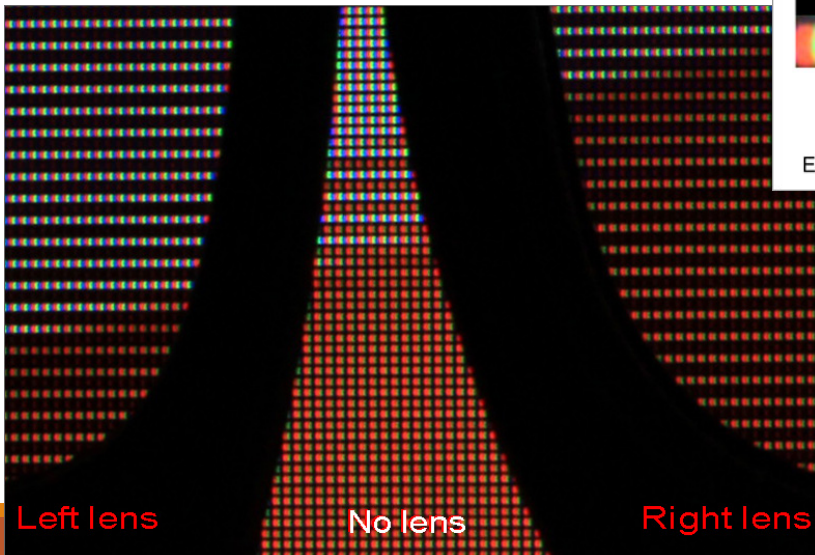
.364 mm / row
(2D mode)

Acer H233H monitor
23" diagonal
1920 x 1080



.266 mm / row

Carl Pisaturo 2012



Left lens

No lens

Right lens

Interference Filters

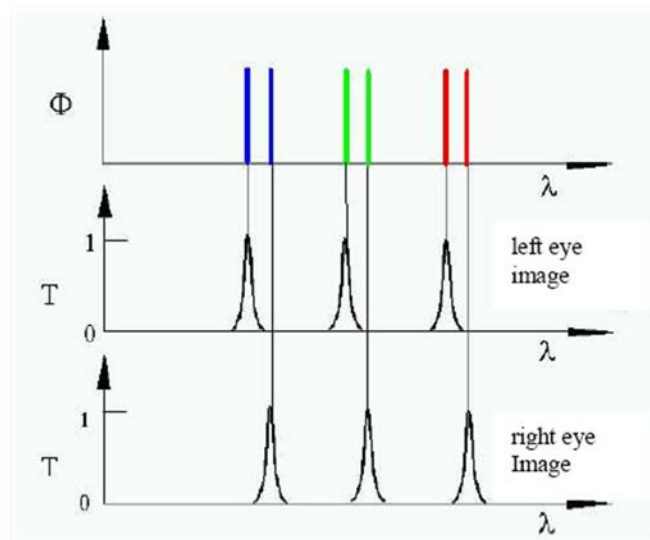
Uses specific wavelengths of red, green and blue for the right eye, and different wavelengths of red, green and blue for the left eye. Example: Dolby 3D



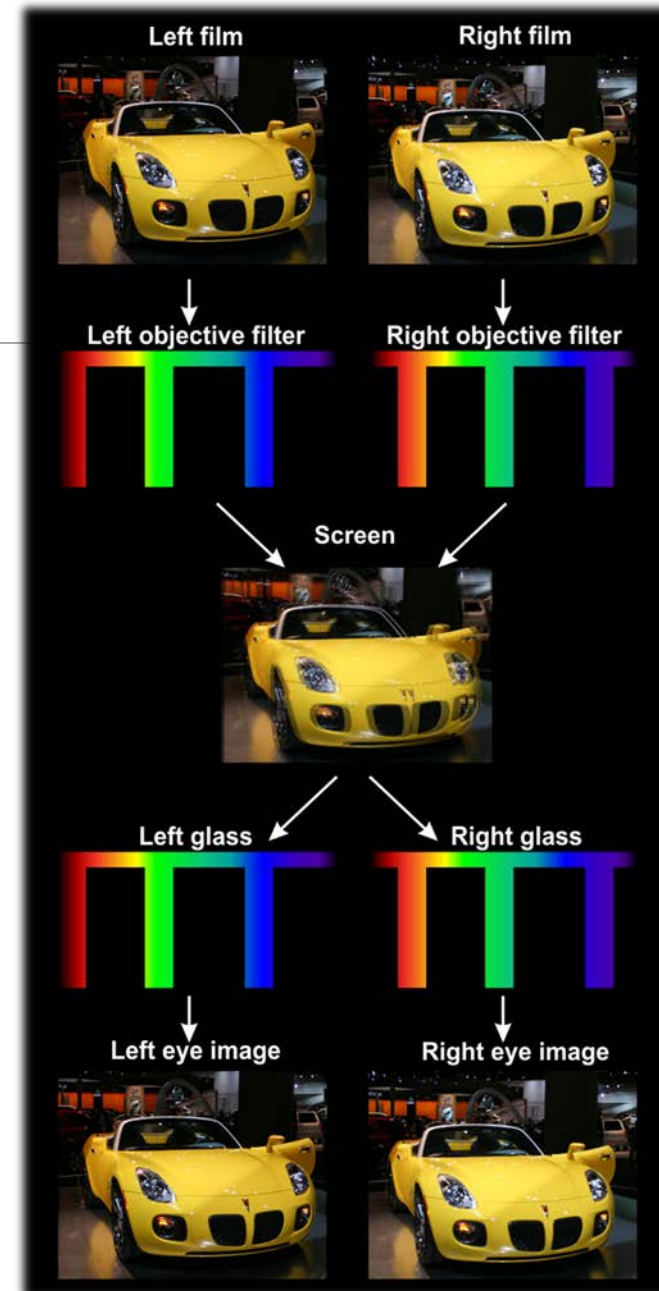
Dolby 3D glasses



Stereo projectors with filters



Stereo projectors with filters



Active Stereo with Shutter Glasses

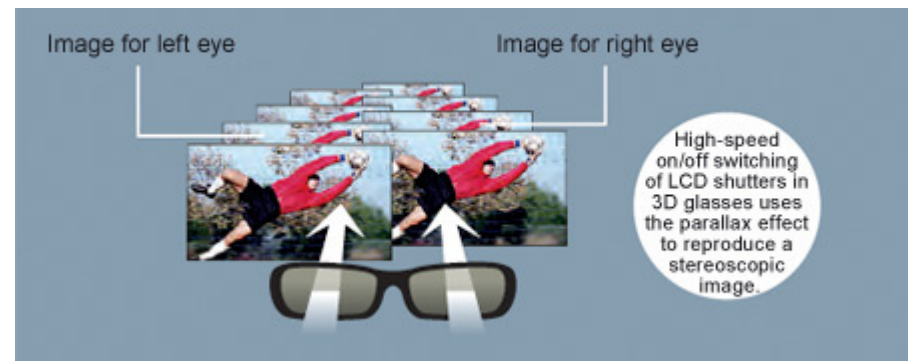
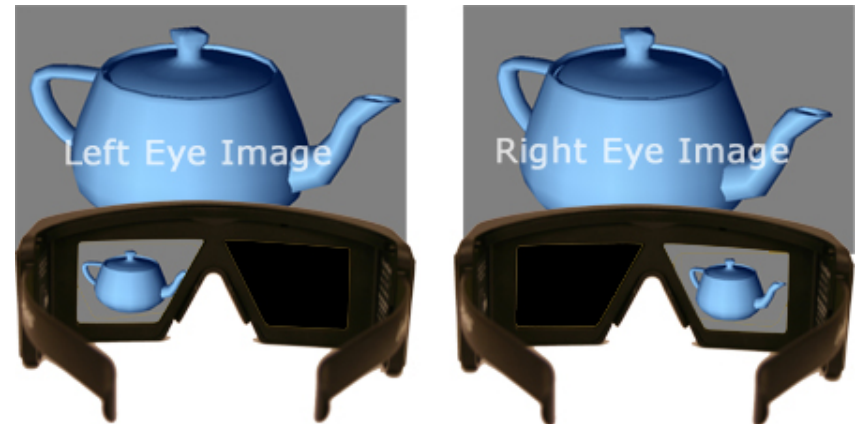
Display alternates between images for left and right eyes at 120+ Hz

Shutter glasses:

- synchronized to display refresh rate
- more expensive than passive glasses (~\$30+)
- require batteries



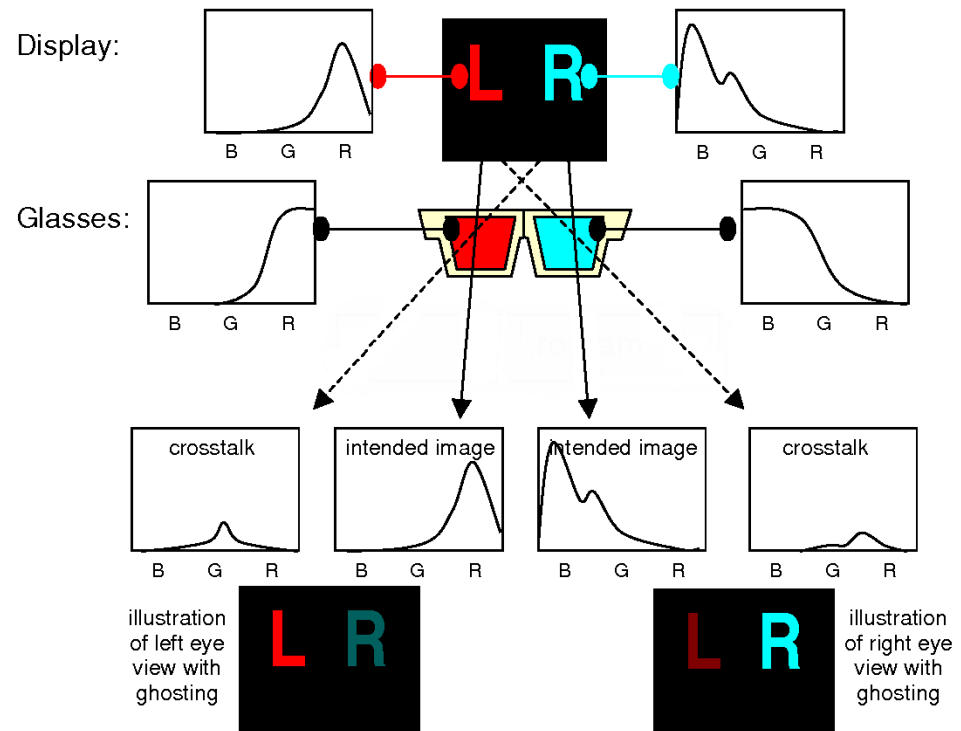
3D shutter glasses



3D Crosstalk – Ghosting

Ghosting is when a **secondary** “ghost” image can be seen along with the primary image.

On stereo displays, the ghost image is the image displayed for the other eye, visible because of **insufficient filtering** by the stereo glasses.



Example: ghosting with anaglyph 3D

Ghosting

Which 3D stereo techniques are prone to ghosting?

Ghosting

Which 3D stereo techniques are prone to ghosting?

All filter-based techniques:

- Autostereo displays
- Anaglyph 3D
- Passive stereo
- Interference filters
- Active stereo

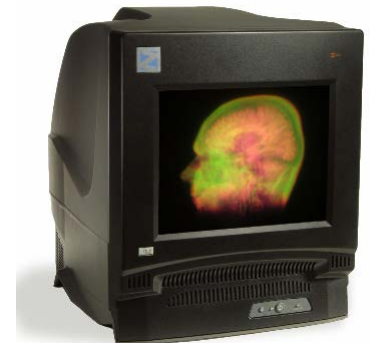
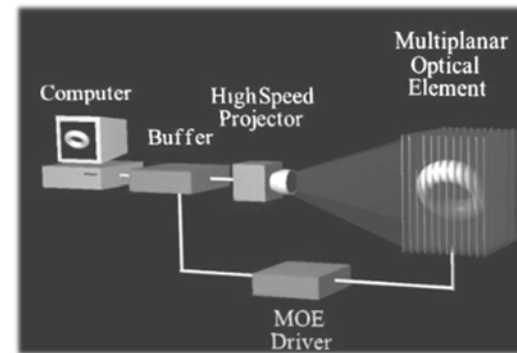
Volumetric Displays

Display a true 3D image

- Looks correct for multiple users
- Each user has correct perspective

Techniques:

- Rotating projected screen
- Rotating LED arrays
- Multi-layered projected screen



DepthCube: 20 layers

3D LED Display



Perspecta Spatial 3D Display



Separate Displays for Each Eye

Stereo created by showing physically separated displays to each eye.

Requires head-worn 3D display

Examples:

- Viewmaster
- Gaming VR headsets
- Google Cardboard
- AR headsets



3D headsets with physically separated displays