Displays for VR

Derek Juba, and Amitabh Varshney

Light Polarization

- Light has a electric (E) and a magnetic field (B)
- Light is polarized if the electric field oscillates in a specific manner
- Possible polarizations: horizontal, vertical, circular (clockwise or ctr-clockwise) and elliptical (clockwise or counter-clockwise)
- Sunlight is not polarized

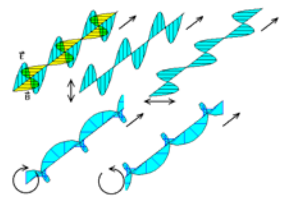
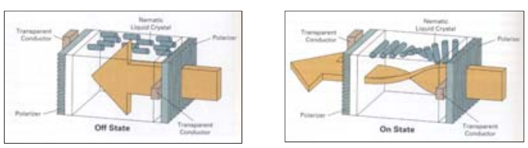


Image from www.uwgb.edu/dutchs/petrolgy/genlight.htm

Liquid Crystal Display



Images from Fig 2.15 *Computer Graphics* by Hearn and Baker

- Passive Matrix: Grid of wires crossing at each pixel
- Active Matrix: Transistor-per-pixel to maintain voltage
- Color: 3 such cells per pixel, dyes for colors

Digital Micromirror Devices

- Texas Instruments DMD chip
  - has >500,000 addressable mirrors
  - 1 Mirror per Pixel
- Light beam reflected from DMD chip to screen
- Bright, better contrast ratio

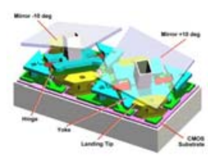
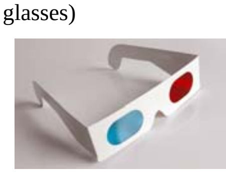


Image Courtesy: Raytheon

Types of 3D Devices

- Stereoscopic Displays
  - Displays separate image in each eye
  - Special glasses or head mounted displays needed
  - Spatially multiplexed (anaglyph or polarized glasses)

•Sony's Personal 3D viewer



Anaglyph

Polarized

Stereo Display Devices: Anaglyphs

- Red/blue or red/green glasses
- If the left eye has the red filter, the images for the right eye are drawn in shades of red
- Analogously for the other eye
- Inexpensive to produce images and to view (use cardboard glasses)

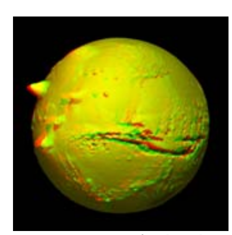


Image courtesy of Paul Bourke

Stereo Display Devices: Polarized Glasses

- Left eye and right eye views are projected on a screen using orthogonal polarizing filters
- Screen material reflects light while preserving the light polarization
- Glasses have corresponding polarizing filters to view appropriate images

Images from www.berezin.com

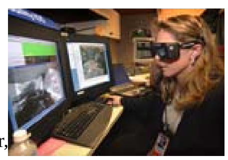
Types of 3D Devices

- Stereoscopic Displays
  - Temporally multiplexed (LCD shutter glasses)
  - More expensive but better quality
  - Shuttering synchronized by RF or IR

3D Active Glasses

Stereo Display Devices: LCD Shutter Glasses

- LCD panel in front of each eye
- When left eye's view is displayed on monitor, the right eye LCD turns opaque while the left eye LCD is clear, and vice-versa
- Infrared emitter synchronizes LCD switching with displayed frames



Crystal Eyes from Stereographics

Stereo Display Devices: Head-Mounted Displays

- Small displays in front of each eye
- Optics engineered to make the images appear several feet away
- Higher-end models are designed to block outside light, and inter-ocular distance adjustments

HMD from Cybermind

Stereo Display Devices: Retinal Displays

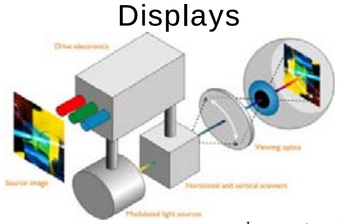


Image courtesy of Microvision

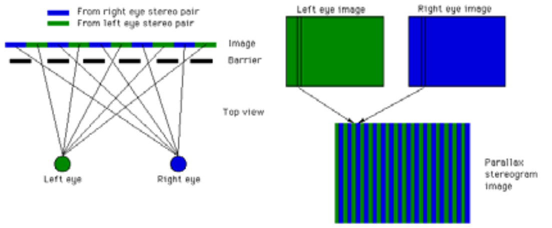
- Different colored lasers scan images directly onto retina
- Advantages: Small, lightweight, could reach very high resolution approaching human vision, very low power consumption

Stereo Display Devices: Autostereoscopic Displays

- Glasses-free Stereo Viewing
- Multiple viewing zones
- Use a lenticular screen to achieve stereo

Image Courtesy of Stereographics

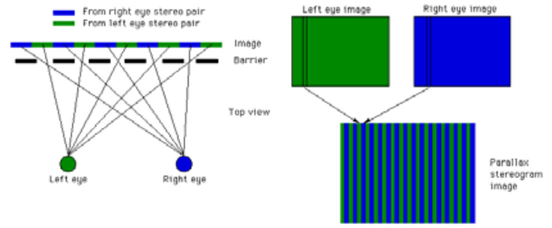
Autostereoscopic Displays: Parallax Barrier Method



Images Courtesy of Paul Bourke

Lecture 9

Autostereoscopic Displays: Parallax Barrier Method



Used since early 1900’s

Images Courtesy of Paul Bourke

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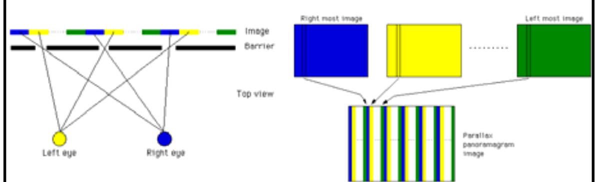
Autostereoscopic Displays: Parallax Barrier Method



Multiple Viewing Zones

Images Courtesy of Paul Bourke

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Autostereoscopic Displays: Lenticular Method

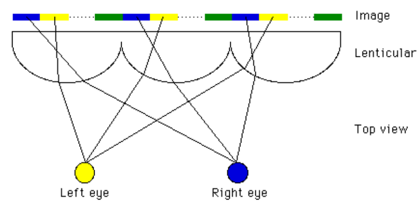

Image Courtesy of Paul Bourke

Lenticular screens on LCD panels

Huge surge of interest ~2003

Stereographics displays, Sharp Electronics laptop, …

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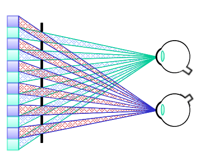
Types of 3D Devices



- Autostereoscopic Displays
  - Parallax-based Displays
    - Expensive
    - Uses either lenslet arrays or parallax barriers
    - Inadvertent color degradation due to refraction in lenslet arrays
    - Cross-talk across views and color channels.

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Stereo Display Devices: Direct Volume Display Devices

Holographic Princess Leia (Star Wars)

Lecture 9

Stereo Display Devices: Direct Volume Display Devices

- Multiple infrared lasers scan glass cube at 30 – 60 Hz
- Glass cube is treated with special ions
- Laser excites the ions to higher energy states
- Ions give off light at a particular voxel (volume element) when they return to the unexcited state
- One-inch cube prototype

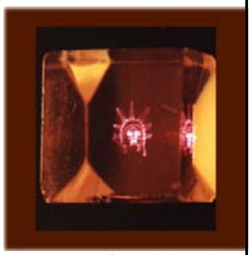
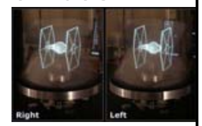


Image courtesy of 3D Technology Labs and Elizabeth Downing

Lecture 9

Autostereoscopic Devices



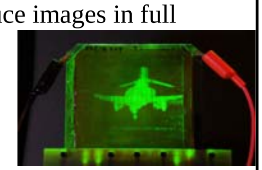
Interactive 360° Light Field Display [Jones et al. 2007]

Volumetric Displays
- Can only show transparent objects
- Uses a participating medium such as vapor or a moving (typically revolving) surface
- Can display an object at different depths so that they do not suffer from vergence-accommodation conflict
- They often fail to show monocular depth cues such as shading, texture gradients, and occlusion

Lecture 9

Holograms

- Introduced by Dennis Gabor in 1948
- Provides depth cues through binocular disparity, motion parallax, accommodation, and convergence much like an object in the real world
- Can be very thin and produce images in full natural color


Dynamic hologram updated every 2 sec [Blanche et al. 2010]

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Holographic Devices

- The acquisition of data for holographic display is difficult
- The amount of computation that is required to compute a hologram is high
- Dynamic updates on the polymers used in holograms are still very slow (0.5Hz)
- The depth of field that can be shown by a hologram is limited

Lecture 9

Other Recent Displays

- OLED (organic LEDs)
- E-Ink
- Pico Projectors

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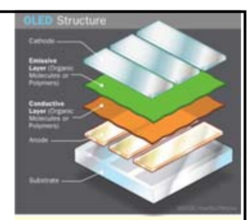
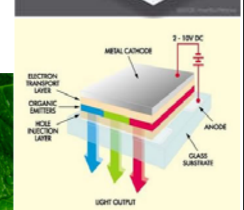
Lecture 9

OLED

- Place a series of organic thin films between two conductors
- Electrical current causes bright light to be emitted
- First developed in early 50's in France by Bernanose *et al.*

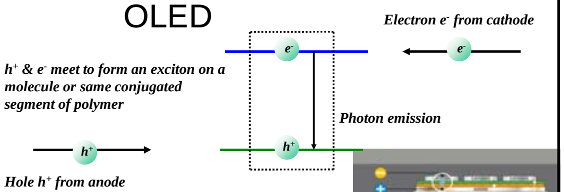




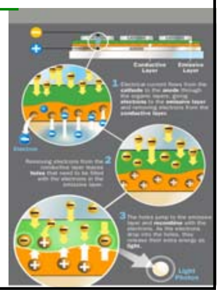
Slide 24

Lecture 9

OLED



- The four layers are collectively 100 to 500 nm thick
- OLED *emits* light



OLED Features

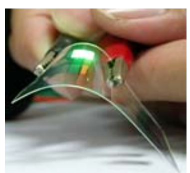
- Thin

http://gizmodo.com/assets/resources/2008/03/Sony_OLED_Review_3.jpg

- Sony XEL-1: OLED TV
- 11" screen, 3mm thin, 1.9kg, 178 deg viewing angle, 1:1,000,000 contrast ratio

OLED Features

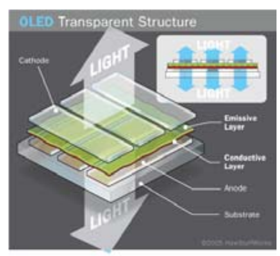
- Flexible

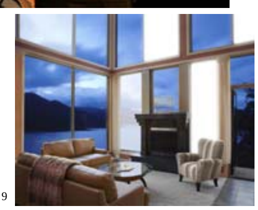


http://www.crunchgear.com/wp-content/photos/oled_01.jpg

OLED Features

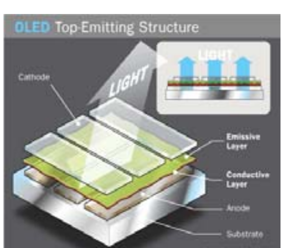
- Transparent





OLED Features

- Top-Emitting

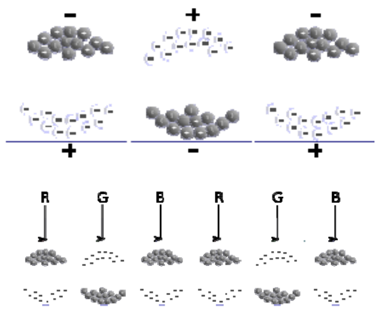


Optimus Maximus Keyboard from Art.Lebedev Studio (Russia): 113 OLED screens, one screen per key

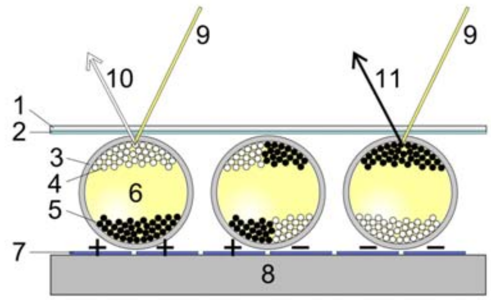
OLED Summary

- **Pros:** Consume much less power than LCD, brighter than LCDs, organic layers can be multi-layered, emit light, thin, …
- **Cons:** Expensive to manufacture (water destroys organic layer – need to use complex sealing/ manufacturing processes)
- OLED material from talks by Joe Shinar (Iowa State), Grant Warfield (Harding Univ), & other sources on the web

Electrophoretic Displays: E-Ink



E-Ink



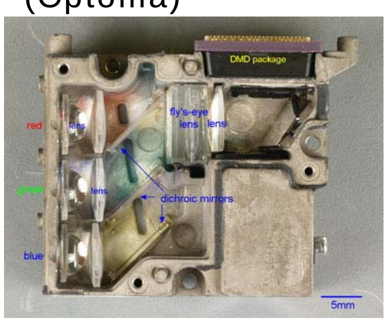
E-Ink

- Spun-off in 1997 from MIT Media Lab
- E-ink: Single company that makes extremely low-power, grayscale, non-illuminated displays on ***most popular*** e-book readers
  - Amazon Kindle, Sony Reader, Barnes and Noble nook, CyBook Gen3, iLiad, etc..
  - Esquire magazine
    http://www.esquire.com/the-side/video/e-ink-cover-video
- The Daily Prophet from Harry Potter

http://www.youtube.com/watch?v=oq_2LiTxhls
http://www.youtube.com/watch?v=3n2xxqMQyfY

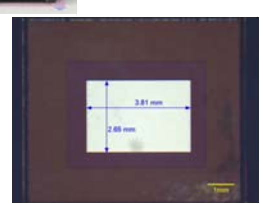
Pico Projectors

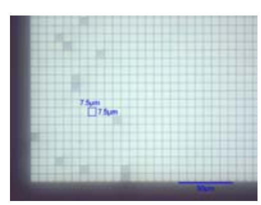
Inside a Pico Projector (Optoma)



http://www.memsindustrygroup.org/i4a/pages/index.cfm?pageID=3675

Inside a Pico Projector (Optoma)



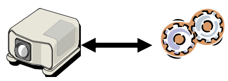


Projector-Camera Opportunities
(Ramesh Raskar)

- Aware Projectors
  - Decoupled display size

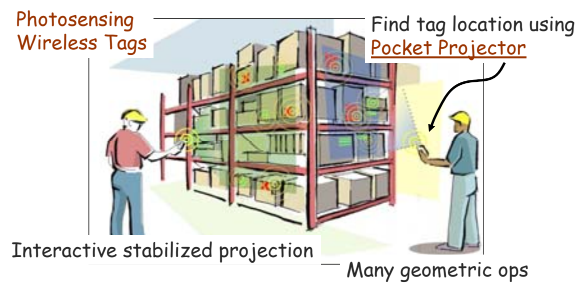
- Image Overlay on Real Objects
  - Decoupled device
  - Non-planar surfaces

- Machine Projection
  - Projector for non-display apps



•R F I D ➡ •R F I•G

• (Radio Frequency Id & Geometry)



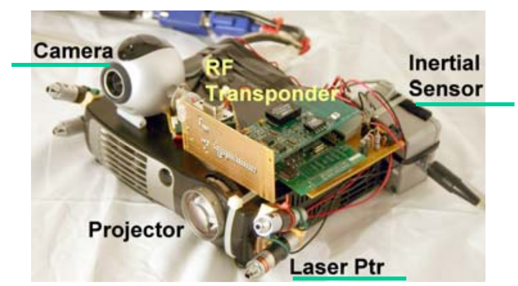
•Siggraph 2004

Using Projector to Interact with Tagged Books in a Library

With RFID, get list of books in RF range

- With Precise Location Data
- **Find which books are out of sorted order !**

Support for handheld projection + RF Reader



Directions for PocketProjector

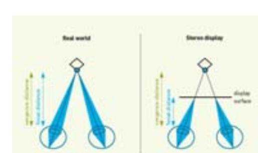
- ‘Personal’ display
  - Shrinking portable devices that carry more data
  - Opportunity to switch between personal and public
- Modular
  - Low cost mass market product
  - Will become building block
    - Platforms: TV, Stereoscopic, Advertising, VideoWalls etc
    - Process: Tiling, Jittering, Superposition, Steering

http://www.ted.com/index.php/talks/pattie_maes_demos_the_sixth_sense.html

Vergence-Accommodation Conflict

Scientific Literature has identified vergence-accommodation conflict causes a variety of psychophysical problems including:

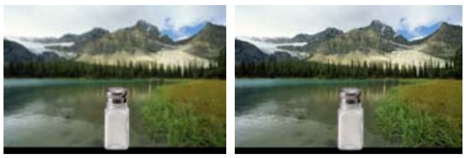
- induced binocular stress
- difficulty in fusing the two images into a stereo pair
- the perception of scene geometry
- discomfort



(Image is from [Kroeker 2010]).

The Challenge

- Popular press has reported a number of viewers complaining about 3D movies giving them headaches, nausea, blurred vision, and other symptoms of visually-induced motion sickness
- A principal suspect is widely believed to be the vergence-accommodation conflict



From: http://gemmahodgson.wordpress.com/tag/salt-shaker/