Input Devices (Part 3) & Output Devices

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Based on material by Dieter Schmalstieg, Oliver Bimber and Skip Rizzo

Recently…

Part 1:

- Desktop Input Devices
- Symbolic Input
- Tracking:
  - Criteria
  - Technology
    - Mechanical, Magnetic,Time of Flight, Inertial, Optical, Hybrid
- Misc. Devices

Miscellaneous Devices

- Gloves
- Pens / Wands
- Hybrid Devices
- Haptics
- Locomotion

Locomotion devices

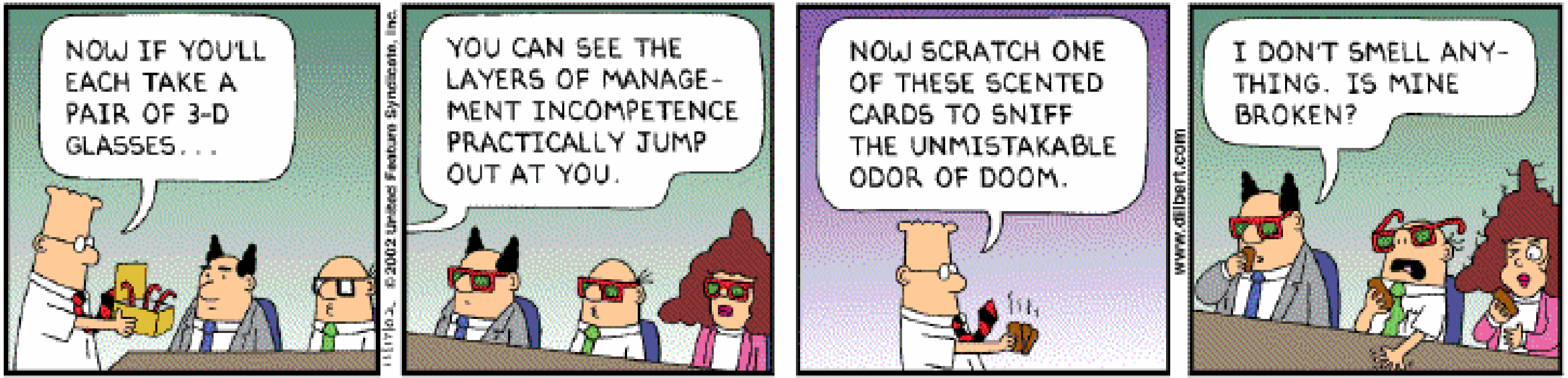
Locomotion = Active Movement

- Treadmills
- Stationary bicycles
- Walking/flying simulations (use trackers)

Locomotion - Prof. Iwata

- Virtual Preampulator
- TorusTreadmill
- GaitMaster 2
- CirculaFloor

Output Devices



Human Sensory Perception

• Vision	~ 70%
• Hearing	~ 20%
• Smelling	~ 5%
• Tasting	~ 4%
• Touch/haptic perception	~ 1%

Display Hardware

- Visual Displays
- Auditory Displays
- Olfactory Displays
- „Taste Display“
- Haptic & Tactile Displays

Immersion

“suspense of disbelief”

Suspension of disbelief is a willingness of a reader or viewer to suspend his or her critical faculties to the extent of ignoring minor inconsistencies so as to enjoy a work of fiction.

- Immersion into a convincing simulation of reality
- Presentation of the artificial reality is done by stimulating human senses
- Stimulation through *Output Devices*

Classification by Immersion

- Desktop Virtual Reality
  - = “Window on World” system
  - Conventional screen + 3D graphics
- Fishtank Virtual Reality
  - Tracking
  - Stereo (shutter glasses)
- Semi-immersive
  - CAVE, Workbench, large stereo screens
- Full Immersion
  - HMD, BOOM, VRD
  - options: audio, haptic interface

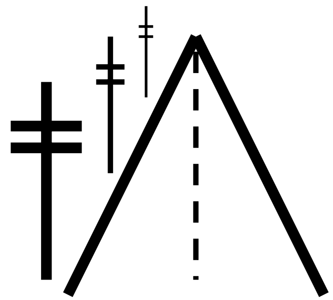
Visual Displays

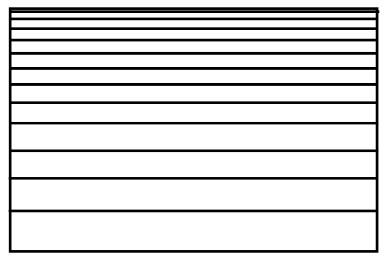
Visual Display Characteristics

- Field of View (FOV), Field of Regard
  - Human FOV ~200°
- Spatial Resolution (dpi)
- Screen Geometry (rect., hemispherical…)
- Light Transfer Mechanism
  - Front/back projection, direct laser->retina
- Refresh Rate (Hz)
- Ergonomics

Depth Cues: How to see in 3D (1)

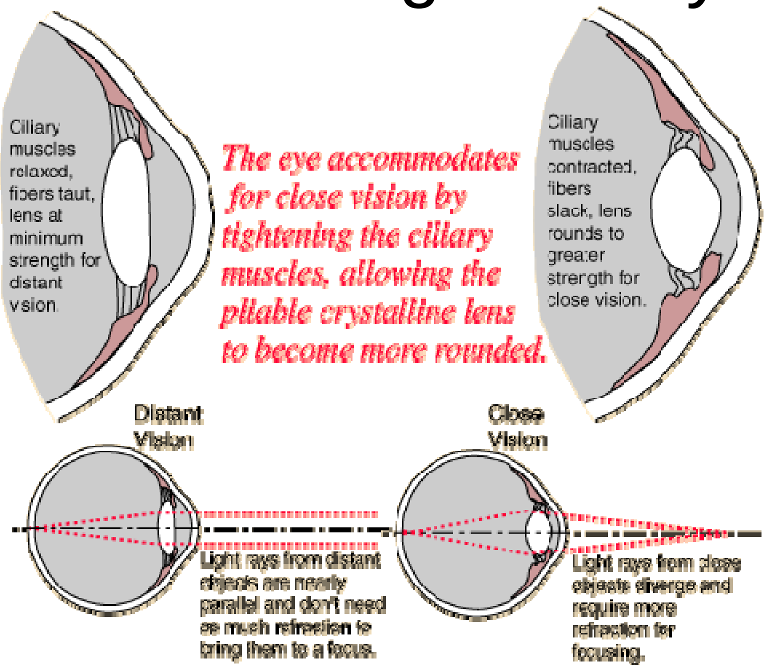
- Monocular static cues
  - Relative size
  - Height relative to the horizon
  - Occlusion (strongest)
  - Linear perspective
  - Shadows
  - Lightning & Aerial perspective
    - Bluish and hazy -> further away
  - Texture gradient
    - More texture detail -> closer

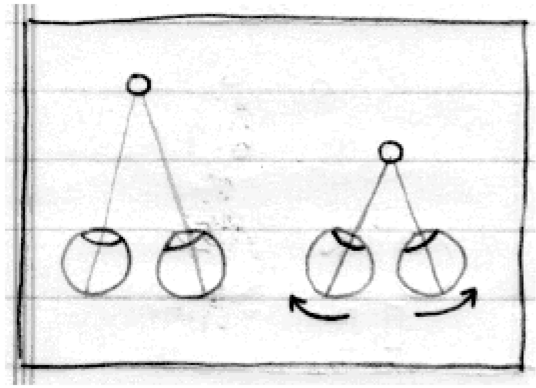




Depth Cues: How to see in 3D (2)

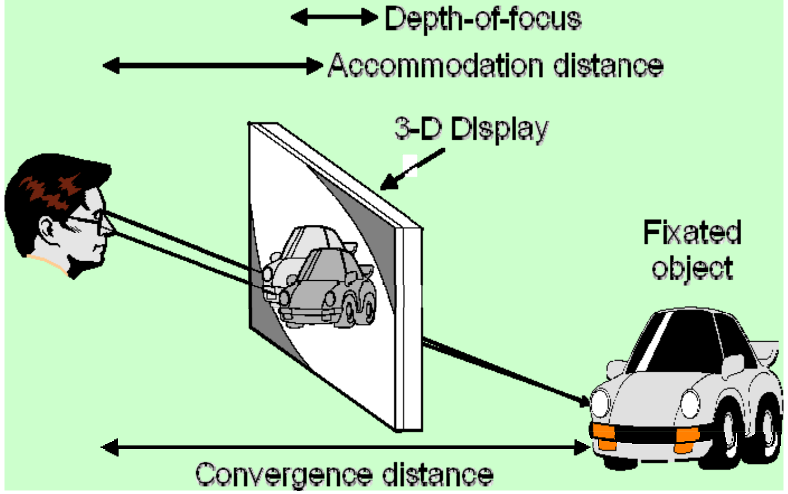
- Oculomotor Cues
  - Derived from muscular tension
  - Accommodation: Change of eye focal length
  - Convergence: eyes looking inwards





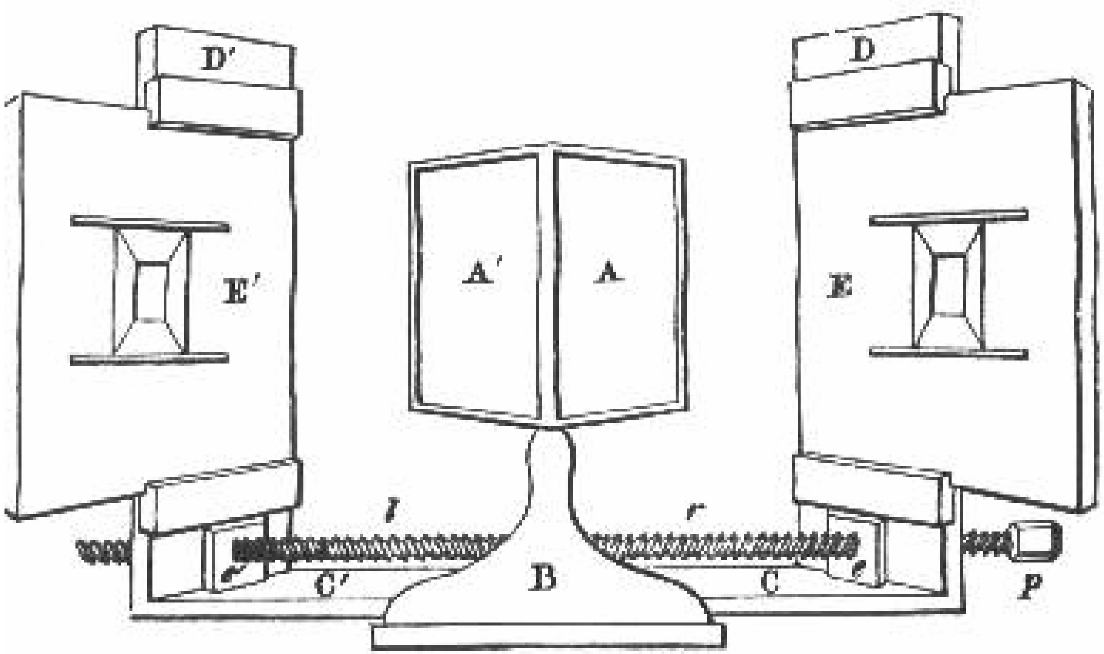
Depth Cues: How to see in 3D (3)

- Motion parallax
  - Closer objects move faster
  - Very strong cue (esp. for far objects)
- Binocular Disparity/Parallax
  - “shift” in left/right images
- Problem with stereo displays: Cue mismatch



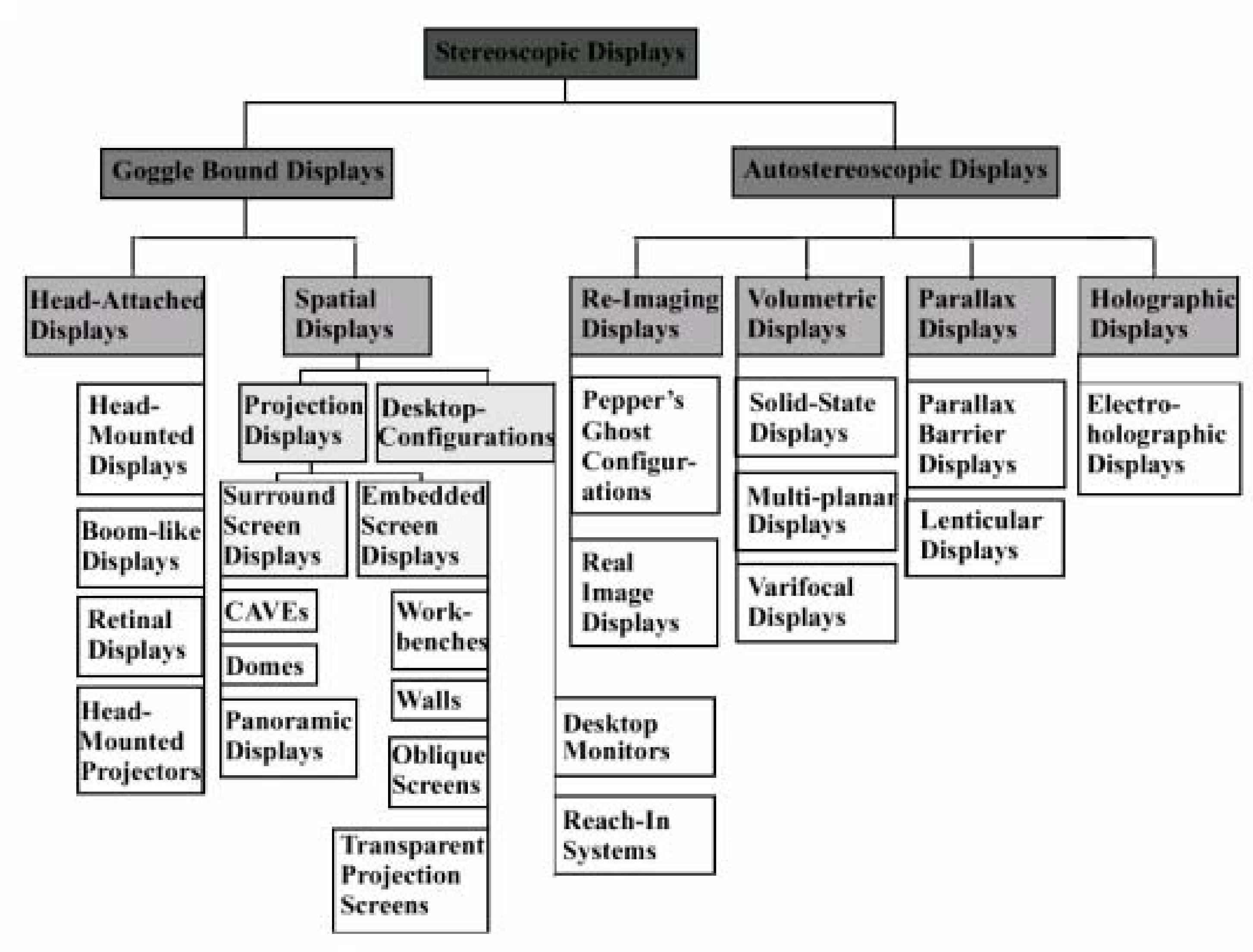
3D (stereo) viewing

- 1838 – Wheatstone stereoscope

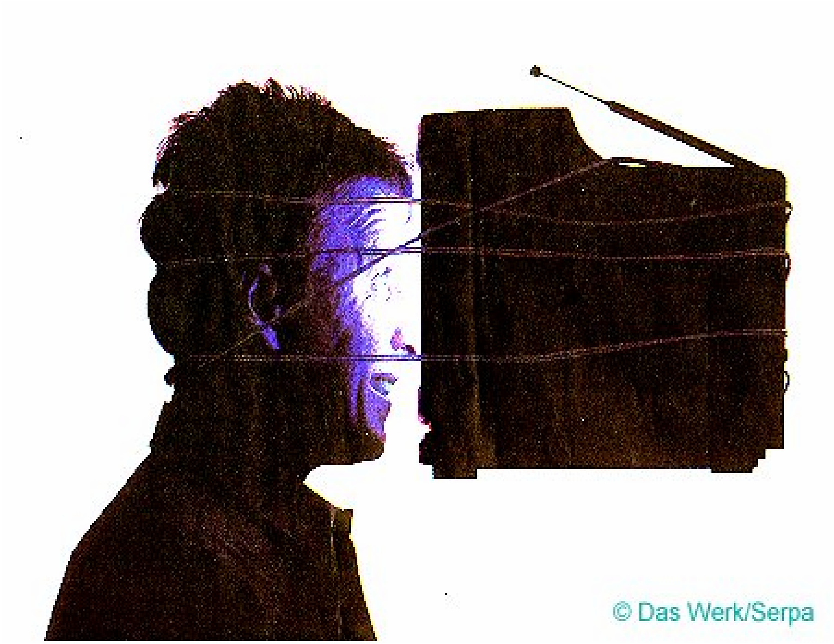


The Wheatstone stereoscope used angled mirrors (A) to reflect the stereoscopic drawings (E) toward the viewer's eyes.

Stereoscopic Displays Today - Overview



Head Mounted Displays



Early prototype

Head Mounted Displays (HMDs)

1968: Sutherland's 1st HMD

FIGURE 3—The mechanical head position sensor in use

FIGURE 4—The ultrasonic head position sensor in use

- Hidden-line graphics
- Mechanical tracking

- **See-through HMD**

Head Mounted Displays (HMD)

- Device has either two screens (CRT, LCD or OLED) plus special optics in front of the users eyes
- User cannot naturally see the real world
- Provides a stereoscopic view that moves relative to the user

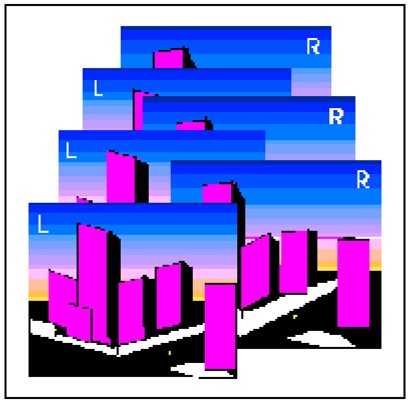
Sony Glasstron: LCD display,
Resolution: SVGA
(832×624 pixels)
FOV: 30 × 22 degrees
Weight: 120 grams

HMD - Stereo Principle

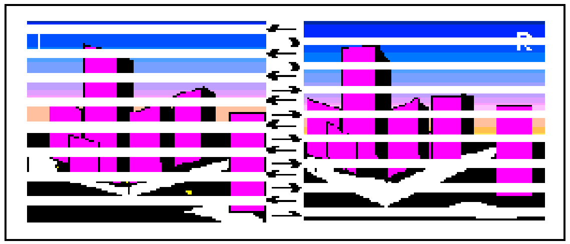
Two oculars

(need DualHead graphics, eg. nVidia GeForce, ATI, Matrox, SGI,…)

Field Sequential

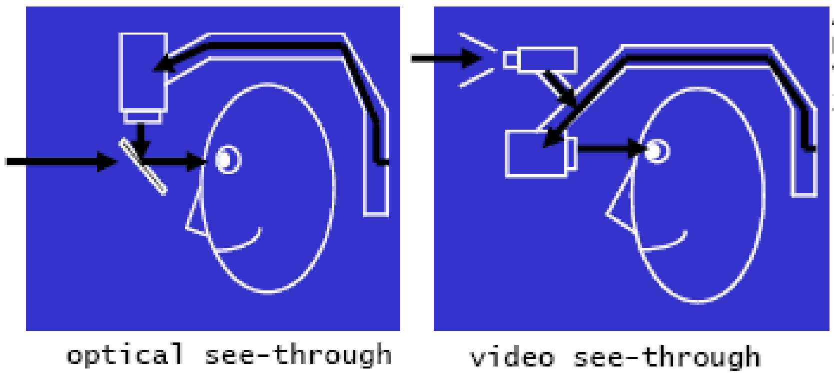


Interleaved stereoscopic



See-through HMDs

- 2 Types:
  - Optical see-through
  - Video see-through
- Used in Augmented Reality Applications



Azuma, R. T. A Survey of Augmented Reality. Presence: Teleoperators and Virtual Environments, vol. 6, no. 4, pp. 355-385, 1997.

HMD - Examples





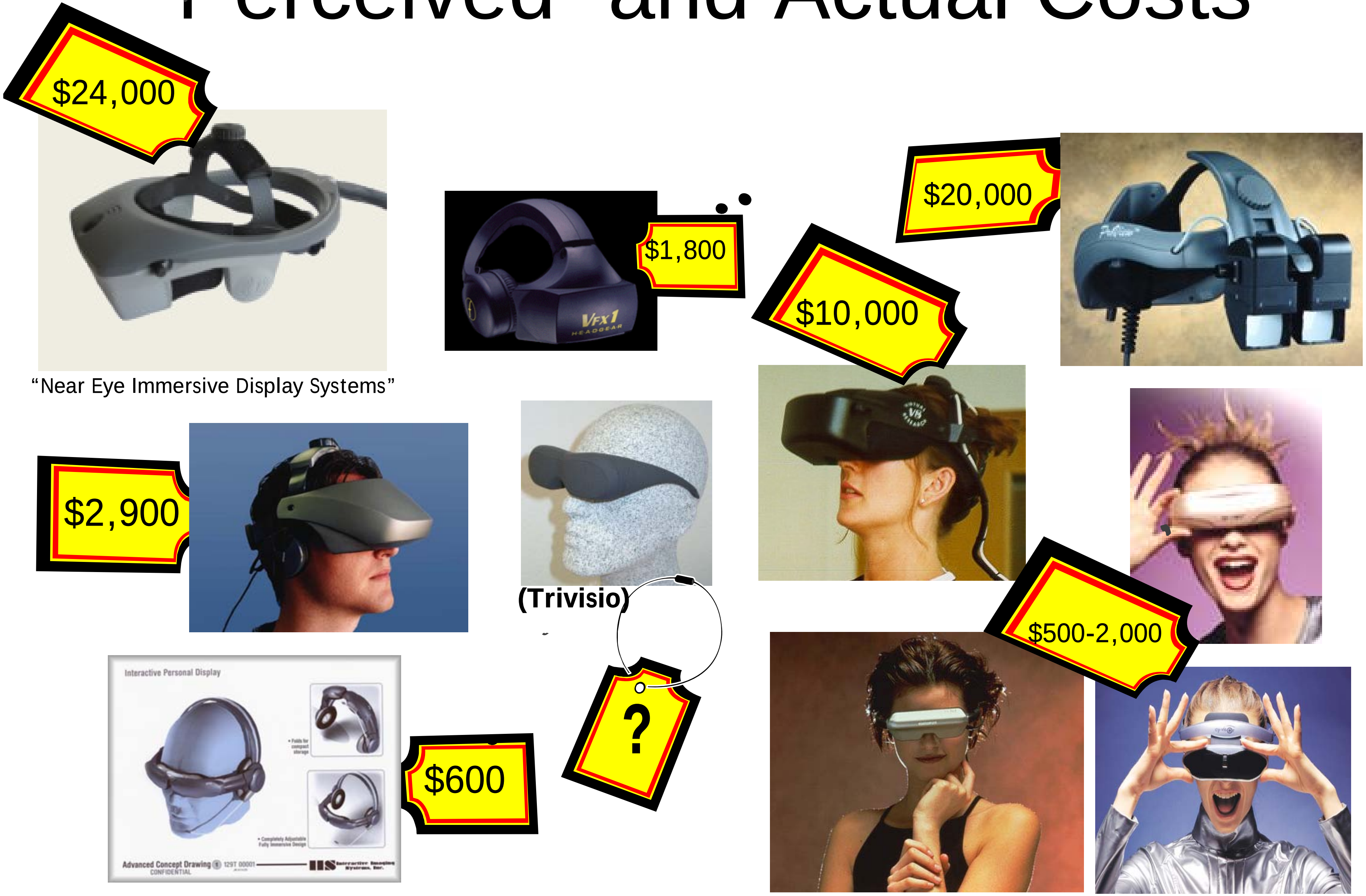



Virtual Binoculars

Active Matrix LCD display,
Resolution: VGA (640x480)
FOV: 30 degrees
IPD: 51–80 mm
Weight: 680 grams

V8 Binoculars (courtesy of Virtual Research Co.)

“Perceived” and Actual Costs



Display Technology - New Head Mounted Displays…

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V920 Display

VIDEO EYEWEAR AT PLAY In 1982 Sony introduced the first flat screen TV, an event many credit as the beginning of the home theater market. More than two decades later, screens still continue to grow in size, with LCDs winning the image quality battle. Now, Icuiti Corporation has made the home theater experience both personal and portable. Icuiti's Video Eyewear is creating a new paradigm in video entertainment—high resolution, LCD quality, in an eyewear format that can be used anywhere, anytime.

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Display Technology - New Head Mounted Displays…

$899 w/3DOF Tracking

Emagin HMD (OLED displays)

HMD - Properties

- Image:
  - FOV (Field of View)
  - Resolution (800x600, 1024x768, 1280x1024)
  - Fully immersive vs. see through
  - Mono vs. Stereo
- Ergonomics
  - Weight & Cables
  - Hygiene
  - Ruggedness
- Cost
- Support (Repairing, ...)

HMDs - Advantages

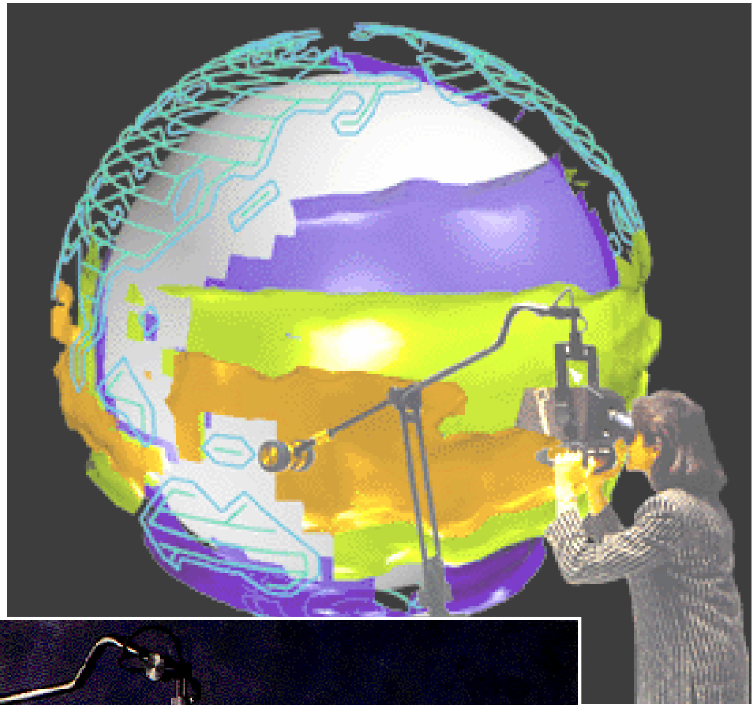
- Provides an immersive experience by blocking out the real world
- Easy to set up
- Does not restrict user from moving around in the real world (…cable length)
- Average quality HMD is now affordable
- Can achieve good stereo quality

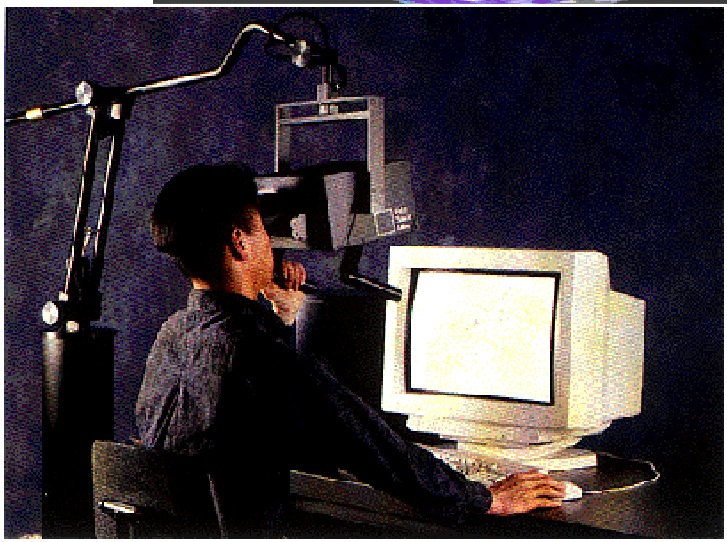
HMDs - Disadvantages

- Limited resolution and field of view (FOV)
  - Does not take advantage of peripheral vision
- No wireless versions available yet
- Ergonomics: sometimes heavy, uncomfortable
- No extended use: max. 30-60min. Cybersickness (!!!)
- See-through HMDs hardly available; Cost > $20,000
- Non see-through:
  - Limited use of input devices
  - Physical objects require graphical represent.
  - Isolation and fear of real world events
- Hygiene

Arm Mounted Display (BOOM)

- “BOOM” = Binocular Omni-Oriented Monitor
- Like a HMD but mounted on an articulated arm
- Mostly use CRT technology
- Most common arm mounted displays developed by Fakespace





BOOM - Advantages

- Provides better resolution than HMDs and generally a higher FOV
- Light weight relative to the user
- Excellent tracking with minimal lag
- Easy to set up and switch users
- Good stereo quality

BOOM - Disadvantages

- Limited user movement
- Like looking through binoculars
- Does not take advantage of peripheral vision
- Requires the user to hold onto the BOOM for control

Virtual Retinal Displays (VRD)

- Scans images directly onto the retina
- Invented at the HIT Lab, Seattle, in 1991
- Two prototypes have been developed (portable and desk mounted system)
- Commercially being developed at Microvision, Inc. (Video)

VRDs – Advantages

- Lightweight relative to the user
- Ability for high resolution and FOV
- Works under all lightning conditions
- Potential for complete visual immersion

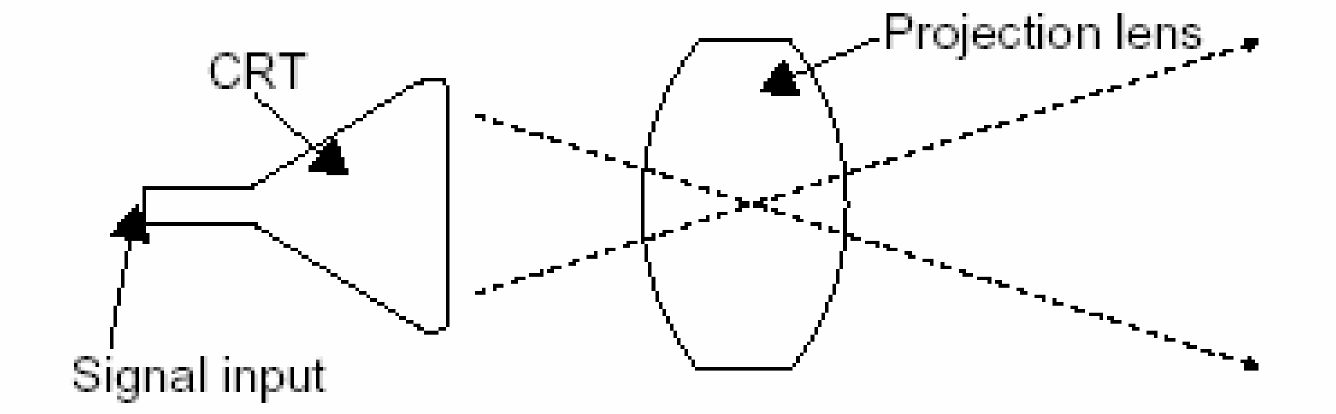
VRDs – Disadvantages

- Currently has low resolution and FOV is small
- Has a long way to go before they become commercially viable and inexpensive enough for mainstream use
- Experimental
- Probably not easily accepted by end users

Basic Projection Technologies

Projection Technologies: CRT

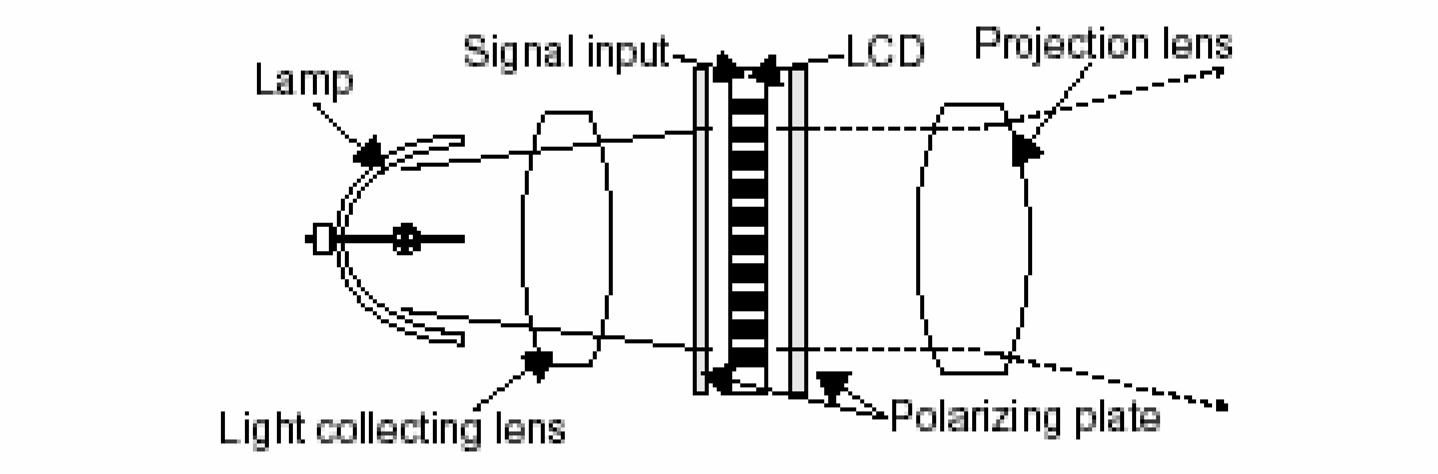
- CRT (Cathode Ray Tube) Projectors



+ High refresh rates (>100Hz) – stereo capable
+ Relatively low cost
– Large and heavy devices
– Low brightness (~250 ANSI lumen)

Projection Technologies : LCD

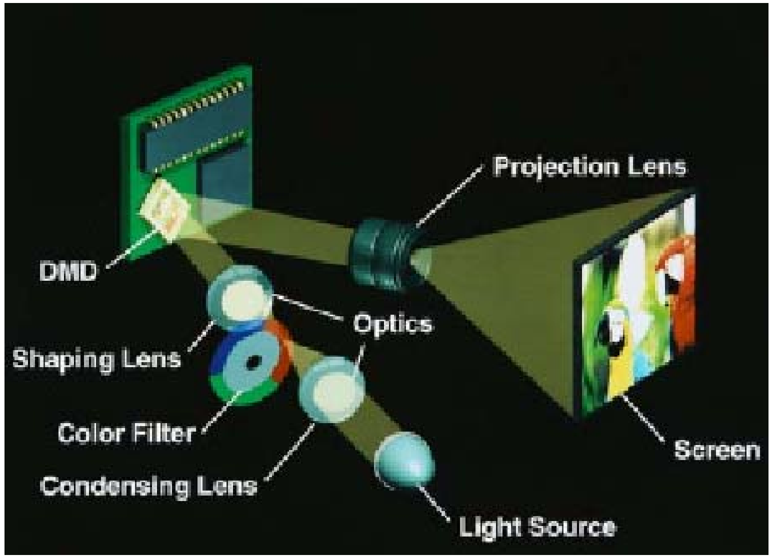
- Liquid Crystal Display (LCD) Projectors

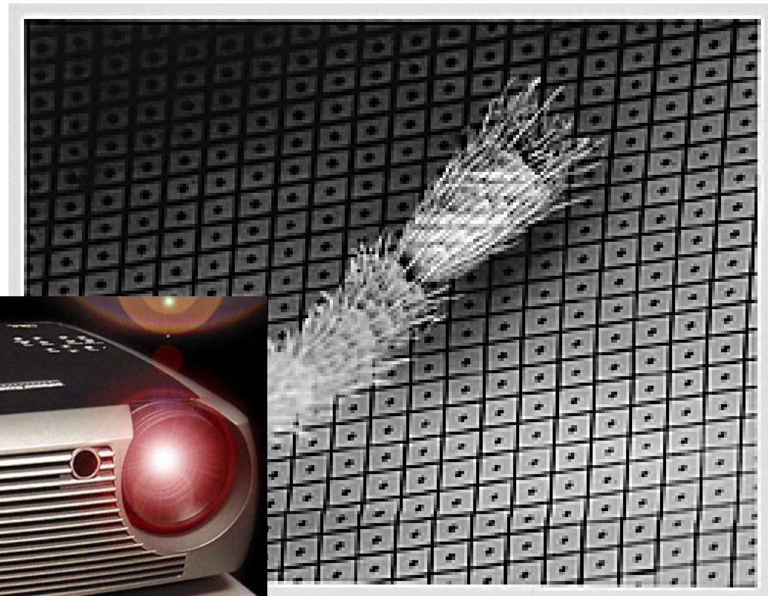


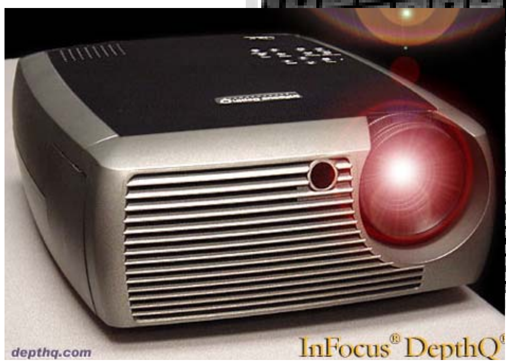
  – Individual grayscale LCD for each color
  – Pixel dimensions <50µm
  + Low cost
  – Poor contrast and black level
  – No stereo possible (Refresh rate <100Hz)

Projection Technologies: DLP

- Digital Light Processing (DLP)
- Fast switching of micro-mirrors (brightness, color)
- Uses information of several frames for artifact compensation -> delay
- High refresh rates possible (>120 Hz)
- Relatively low costs

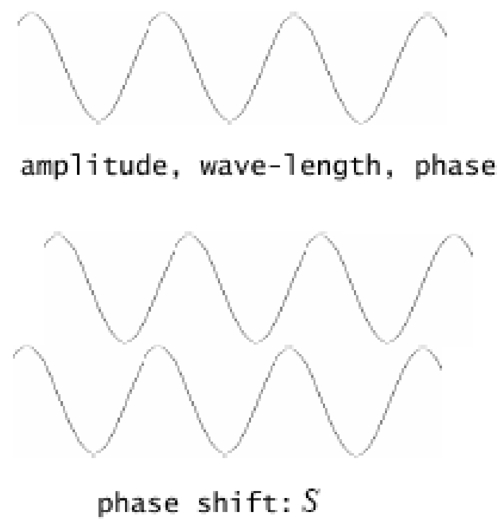






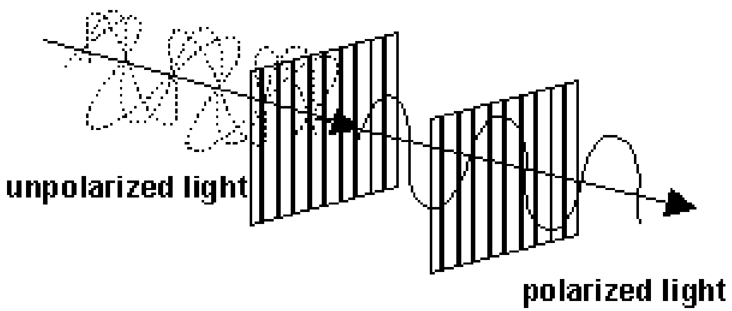
Polarization

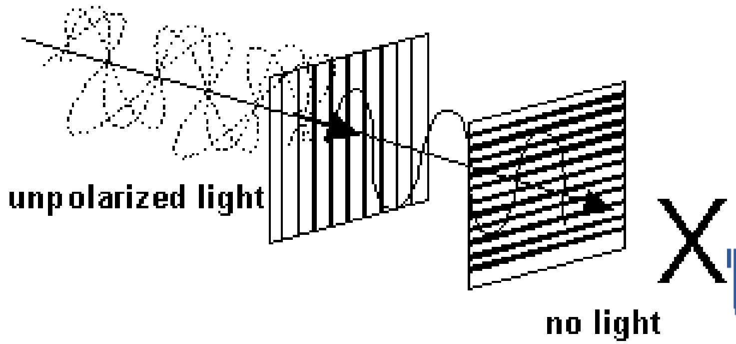
- Polarization filters used to create „different“ images for left and right eye
- Light is an electro-magnetic wave with
  – Amplitude (intensity)
  – Wave-length (color: visible light: 380nm – 750nm)
  – Phase



Polarization

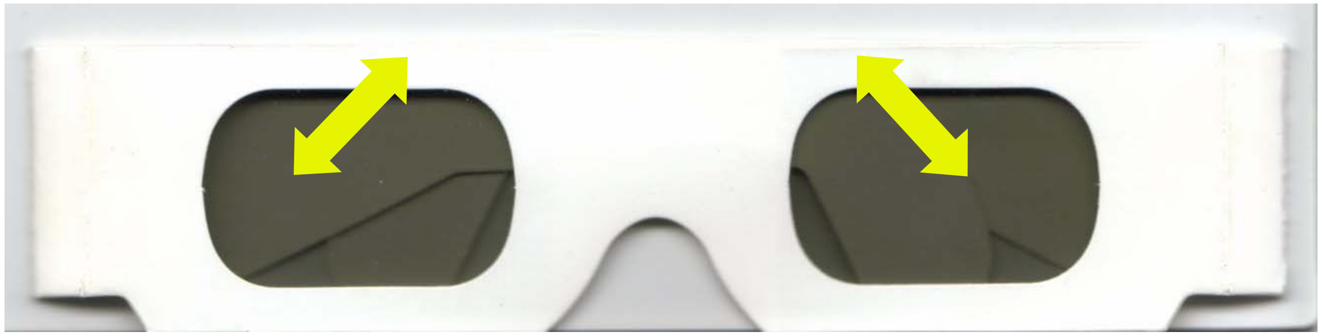
- Use two projectors
  - Left: vertical filter in front of the lens
  - Right: horizontal filter in front of the lens
- Wear glasses with polarization filters
  - Left eye: vertical
  - Right eye: horizontal





Polarization glasses

- Very cheap, paper + plastic foil
- Trick: use +/-45° -> no wrong side wearing



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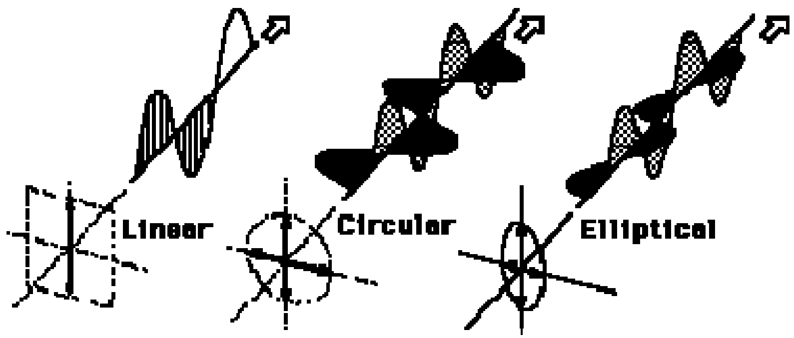
Virtual Reality

Polarization

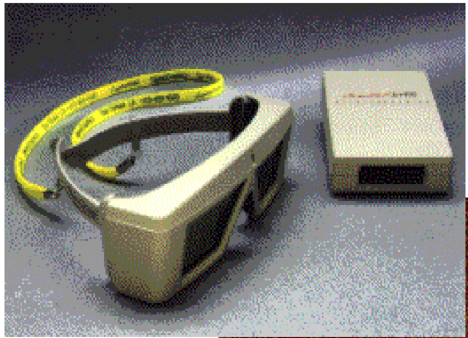
- Linear polarization
  – Can't tilt head
  – Little ghosting
- Circular polarization
  – More involved physics
  – Principle: counter clockwise / clockwise
  – Allows arbitrary head orientations
  – In general more ghosting than linear polarization

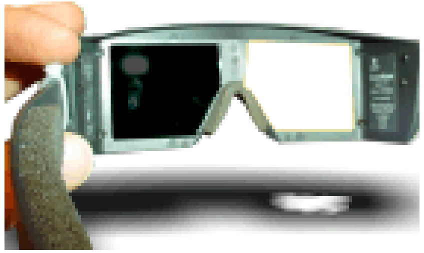


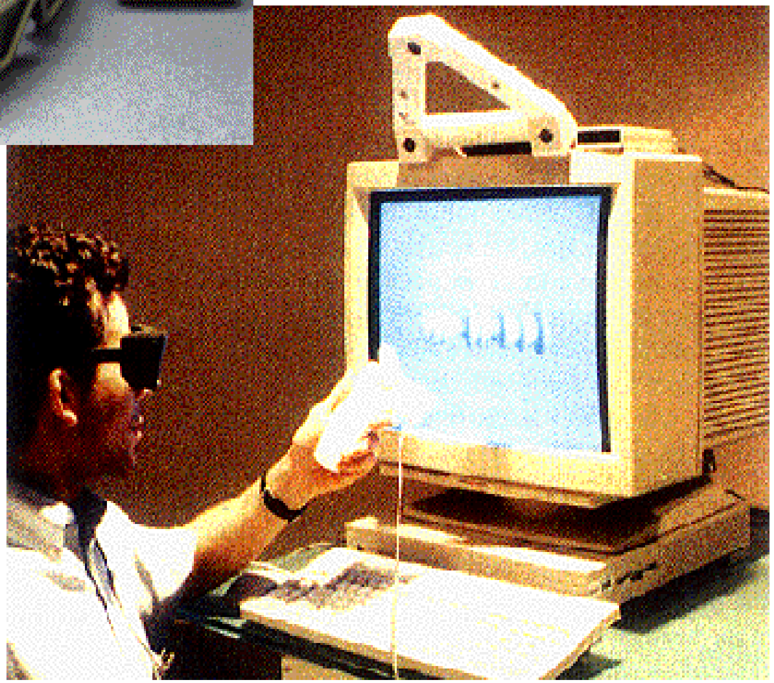
Stereo Monitor

- Ordinary PC
  equipped with emitter
- Active stereo:
  active switching
  e.g. shutter glasses
- Passive stereo: e.g.
  anaglyph stereo
  (red/blue), polarized
  filters

LCD Shutter Glasses







- Monitors with high refresh rate (>100Hz)
- show stereo image pairs sequentially
- monitor and eye glass are synchronized
- every eye sees “its” image

Stereo Monitor - Advantages

- Least expensive in terms of additional hardware over other output devices
- Allows usage of virtually any input device
- Good resolution
- User can take advantage of keyboard and mouse

Stereo Monitor - Disadvantages

- Not very immersive
- User really cannot move around
- Does not take advantage of peripheral vision
- Ghosting
- Occlusion from physical objects can be problematic

Projection Displays

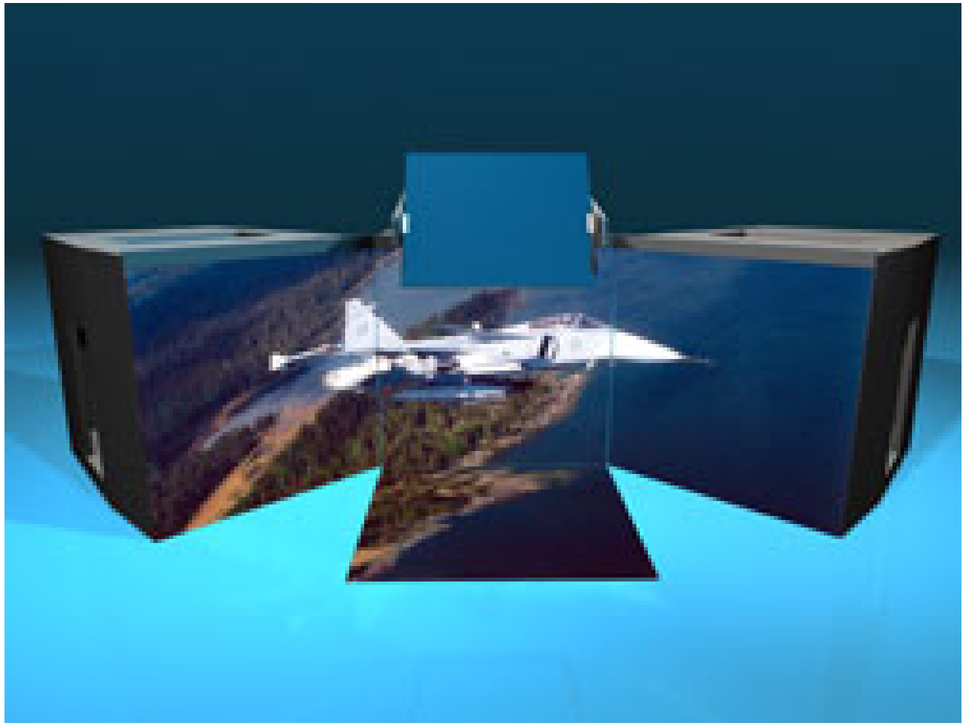
CAVE (1)

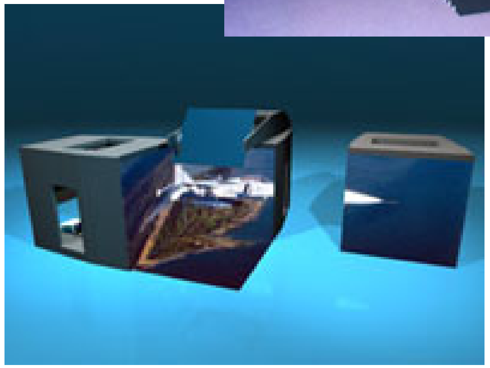
"Computer Assisted Virtual Environment" ™

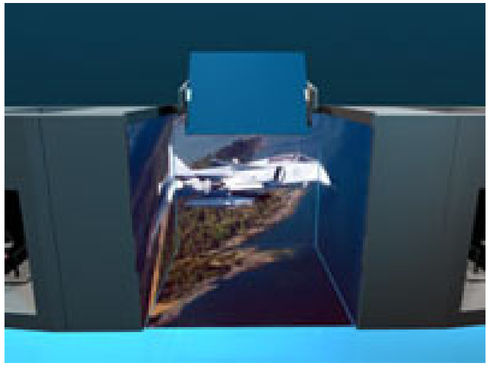
- Has 3 to 6 large screens
- Puts user in a room for visual immersion
- Usually driven by a single or group of powerful graphics engines – nowadays PC cluster

CAVE (2)

RAVE







"Reconfigurable Automatic Virtual Environment"

CAVE - Advantages

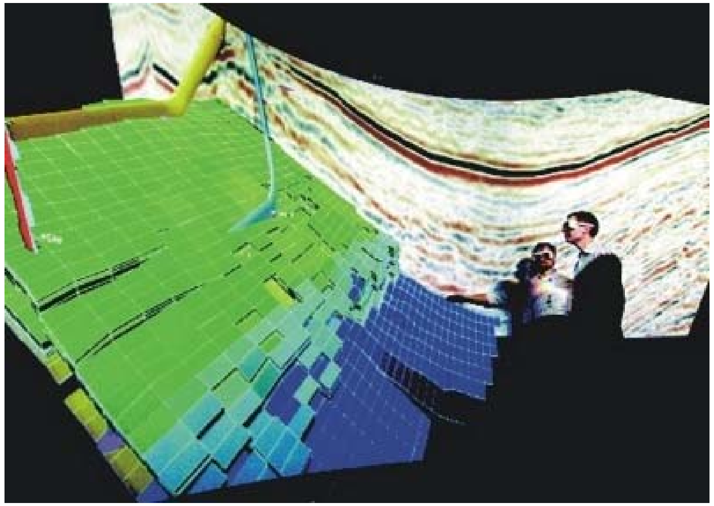
- Provides high resolution and large FOV
- Uses peripheral vision
- User only needs a pair of light weight shutter glasses for stereo viewing
- User has freedom to move about the device
- Has space to place props (cockpit etc.)
- Environment is not evasive
- Real and virtual objects can be mixed in the environment
- A group of people can inhabit the space simultaneously (only tracked user sees correct stereo)

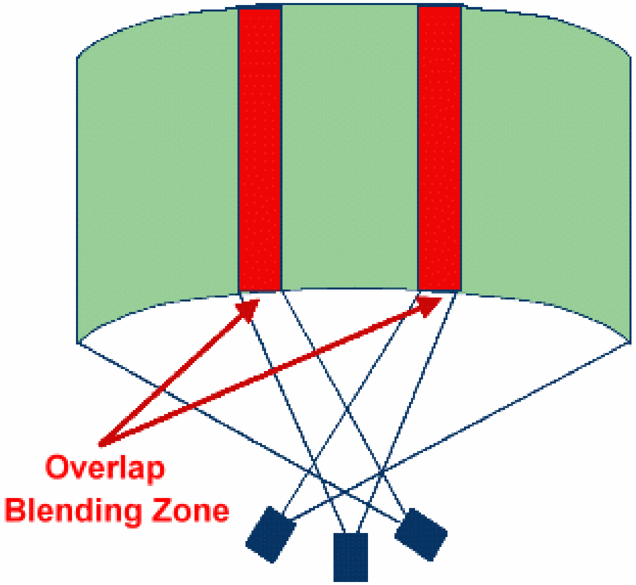
CAVE - Disadvantages

- Very expensive (approximately 1 Million EUR)
- Requires a large amount of physical space
- Projector calibration must be maintained
- Only 1-2 users can be head tracked
- Stereo viewing can be problematic
- No direct interaction possible
  - No “walking around” an object as with HMD
- Physical objects can get in the way of graphical objects

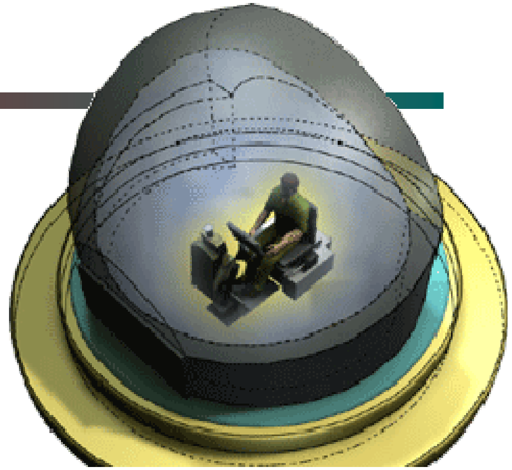
Curved Displays

- Cylindrical or hemipherical screen
- Requires distortion correction
- Common in industry

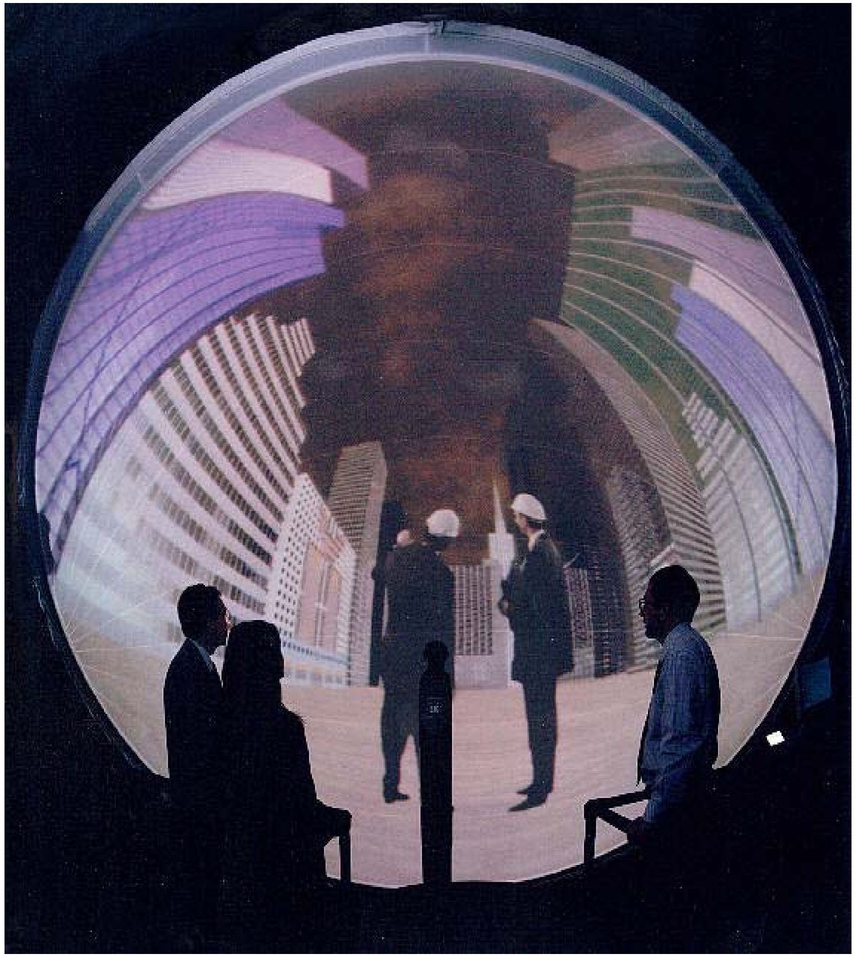


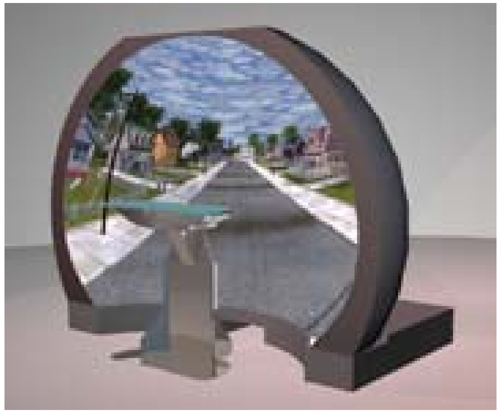


Vision Dome



Spherical Display





VisionStation

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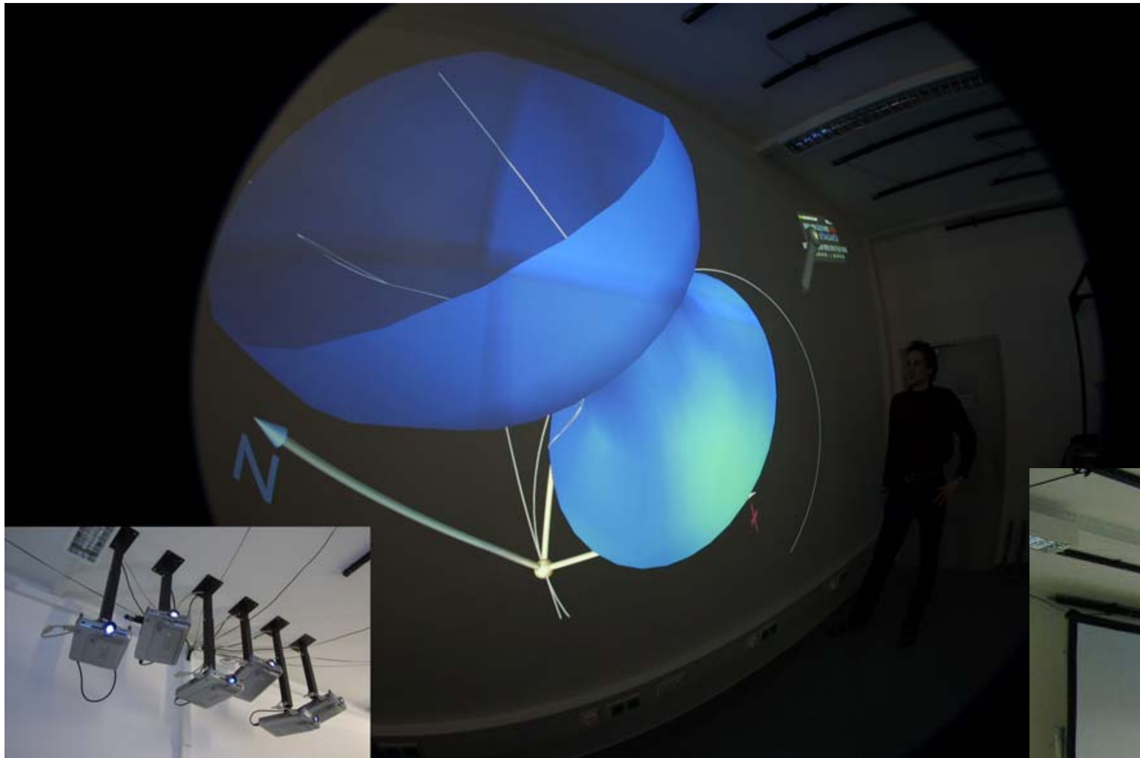
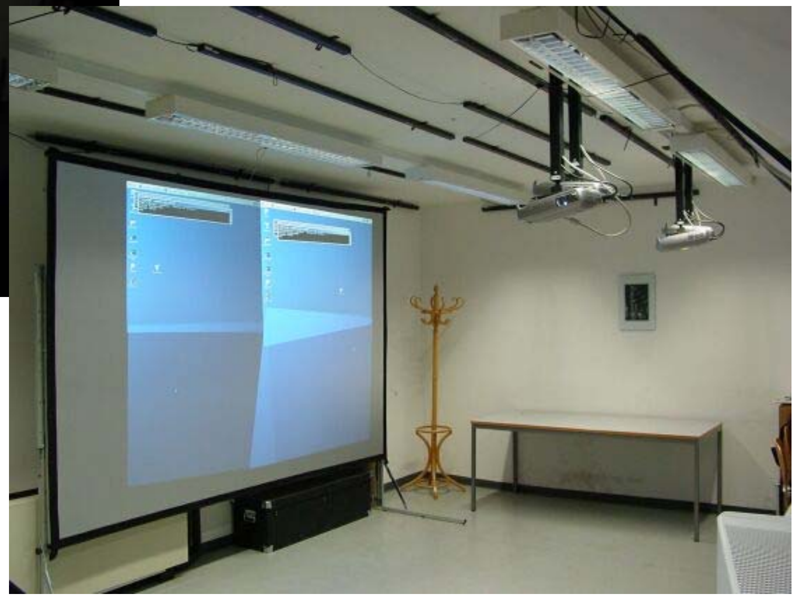
Tiled Projector Display

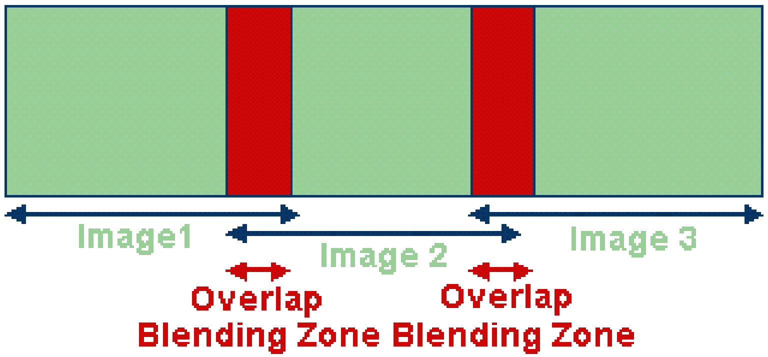


StubeRena
Gottfried Eibner, 2003

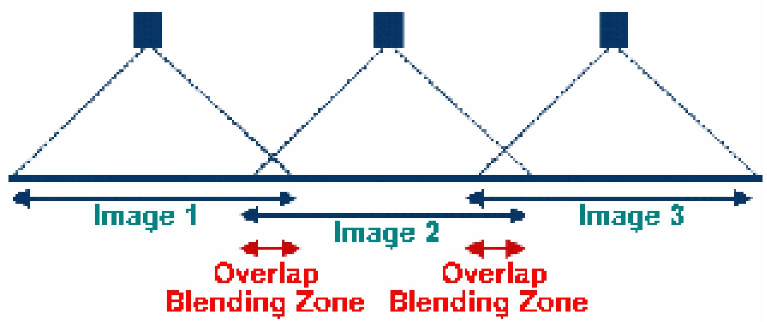


Projection Walls

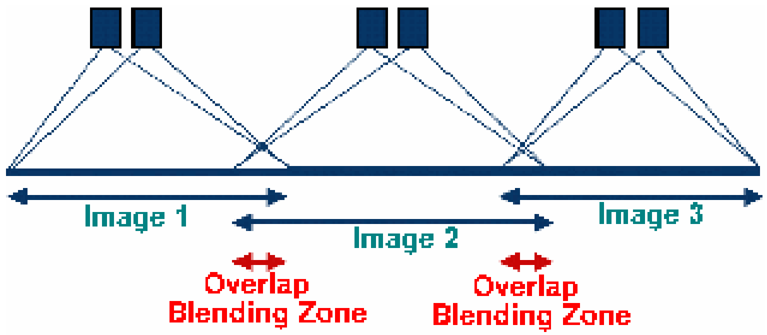
- Active or passive stereo
- Multi-projector setup
- Overlap, edge blending
  - under development: Nvidia driver support



active



passive



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