Special Topics in Virtual Reality

Display Devices 1/2

http://tinyurl.com/STVR2019

Anton L. Fuhrmann
2019

Display Devices

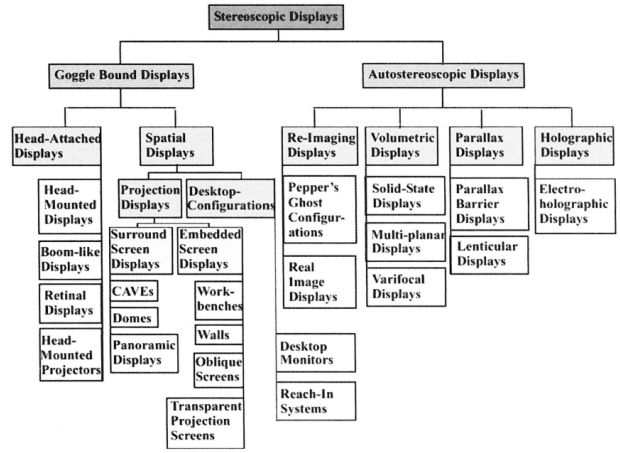
Stereoscopic Output

- Desktop Screens
- Head-Mounted Displays
- Parallax Screen Displays

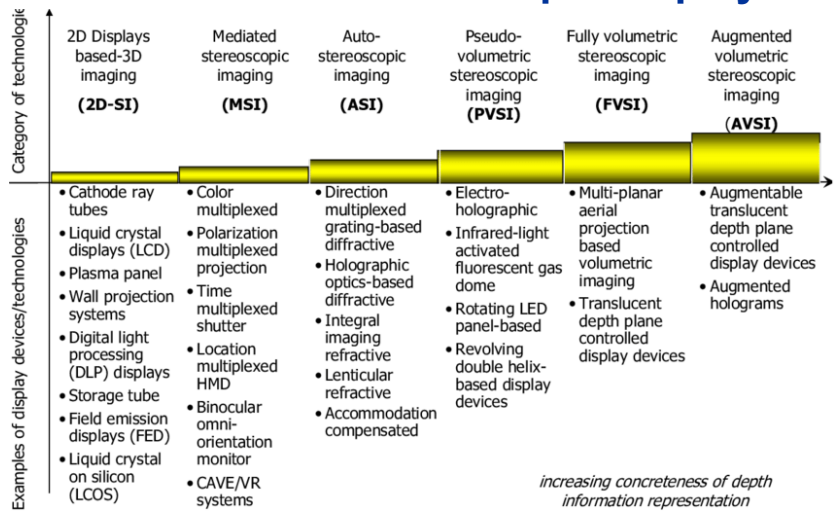
„Exotic Displays“

- Volumetric Displays

Classification of stereoscopic displays

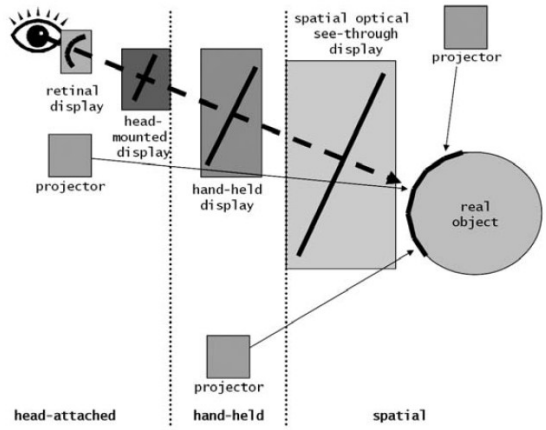


Classification of stereoscopic displays

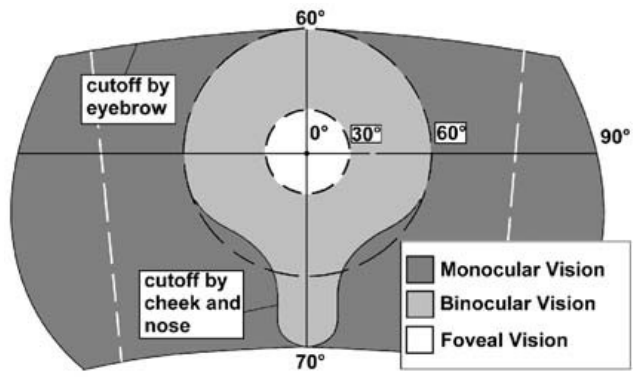


Opiyo, Eliab. (2006). Analysis of the Relevance of the Emerging Visualization Technologies and Systems to Spatial Shape Design.

Classification of AR displays



Human Field of View



[Bimber2005]

Head-Mounted Display (HMD)

- head-mounted (!) helmet, goggles, clips, ...
- one or two displays directly in front of eyes
- two displays → perfect stereo channel separation!
- display technology:
  - CRT
  - LCD
  - laser (retinal displays)
  - projector
- type: immersive, see-through, video see-through

Head-Mounted Display History

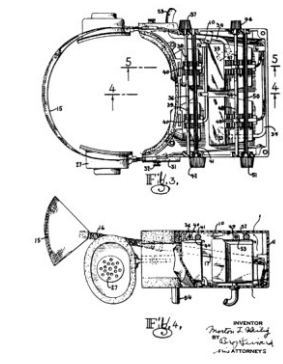


Figure 1.4: *Heilig's early Head-Mounted Display patent [Heilig 1960].*

- 1960 Heilig

- 1963 Hall, Miller

Head-Mounted Display History

•The “Sword of Damocles”
https://en.wikipedia.org/wiki/The_Sword_of_Damocles_(virtual_reality)

•vector display: “3000 lines at 30 frames per second”

•ultrasound & mechanical tracking

•CRT see-through display

Sutherland, I. E. (1968). "A head-mounted three dimensional display". Proceedings of AFIPS 68, pp. 757-764

see also:
Sutherland, I. E. (1965). "The Ultimate Display". Proceedings of IFIP 65, vol 2, pp. 506-508

Head-Mounted Display History

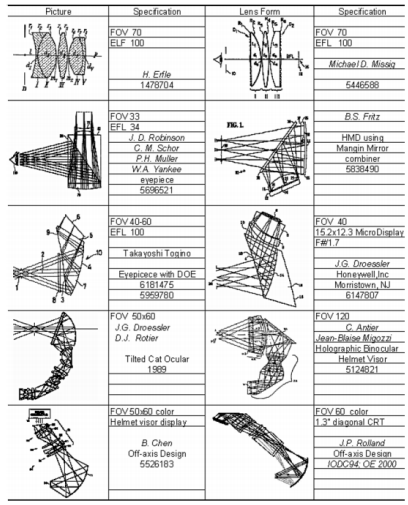
•The “Sword of Damocles”
https://en.wikipedia.org/wiki/The_Sword_of_Damocles_(virtual_reality)

Sutherland, I. E. (1968). "A head-mounted three dimensional display". Proceedings of AFIPS 68, pp. 757-764

Head-Mounted Display (HMD)

- optical see-through
  - semi-transparent mirror
  - overlay over real world
  - brightness problem
  - occlusion problem
- video see-through
  - real world via camera composited
  - occlusion solvable
  - only video resolution of real world (~HD)

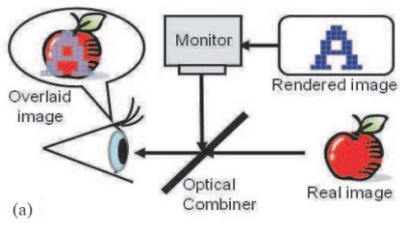
optical see-through HMD



other optical configurations

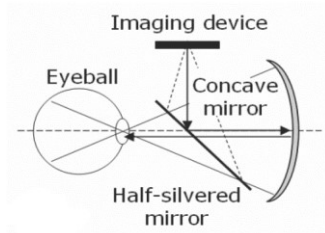
(3D VIS Lab, University of Arizona - "Head-Mounted Display Systems" by Jannick Rolland and Hong Hua)

half-mirrored see-through HMD



[Haller2007]

half-mirrored see-through HMD



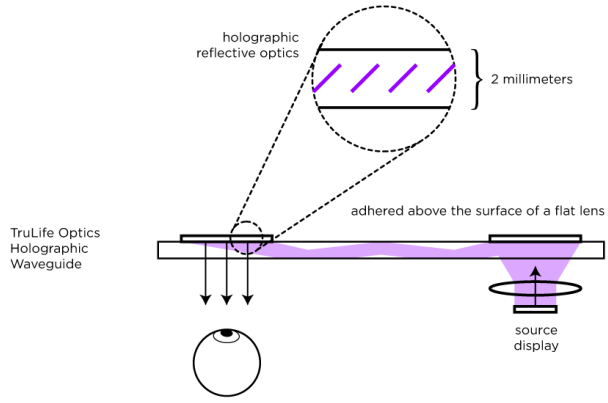
display via half-silvered mirror as overlay (“add”) over reality

Advantage: undistorted view of reality in realtime an wide FoV

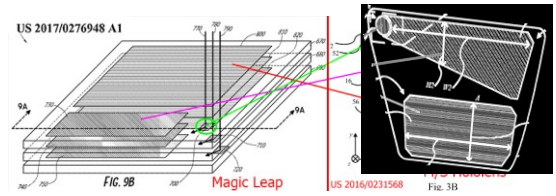
Disadvantage: no complete occlusion, only visible against darker background

waveguide see-through HMD

waveguide see-through HMD: Principle



waveguide see-through HMD



pinlight see-through HMD

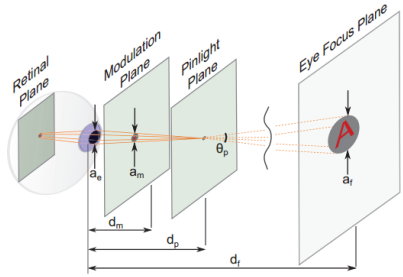


Figure 2: *Pinlight Projection. A defocused point light source, or* pinlight, *placed near the eye is coded with a spatial light modulator to create a narrow field of view image that appears in focus without the use of refractive or diffractive optics.*

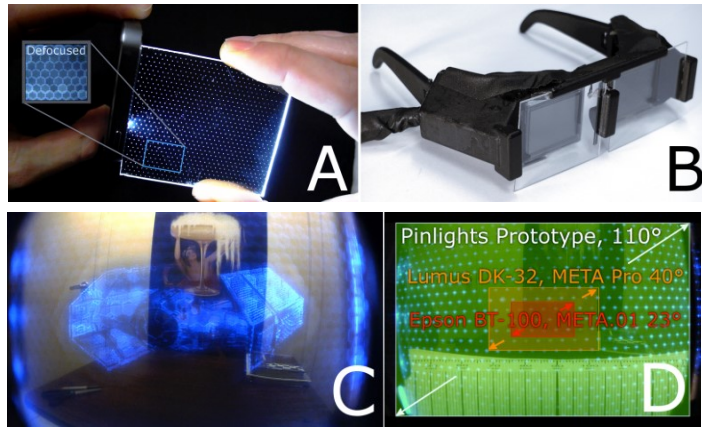
defocused pinlights act as “projectors”, projecting a virtual image through an LCD on the retina

Advantage: wide FoV

Disadvantage: preprocessing dependent on eye position, eye positions has to be measured

Maimone, A., Lanman, D., Rathinavel, K., Keller, K., Luebke, D., Fuchs, H. 2014. Pinlight Displays: Wide Field of View Augmented Reality Eyeglasses using Defocused Point Light Sources. ACM Trans. Graph. 33, 4, Article 89 (July 2014), 11 pages. DOI = 10.1145/2601097.2601141 http://doi.acm.org/10.1145/2601097.2601141.

pinlight see-through HMD



Maimone, A., Lanman, D., Rathinavel, K., Keller, K., Luebke, D., Fuchs, H. 2014. Pinlight Displays: Wide Field of View Augmented Reality Eyeglasses using Defocused Point Light Sources. ACM Trans. Graph. 33, 4, Article 89 (July 2014), 11 pages. DOI = 10.1145/2601097.2601141 http://doi.acm.org/10.1145/2601097.2601141.

diffractive see-through HMD

Vuzix / Nokia Waveguide diffractive combiner (with laser pico projector)

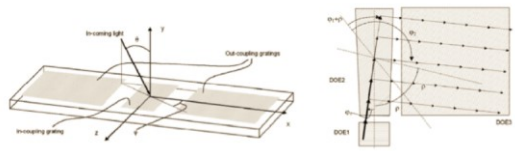
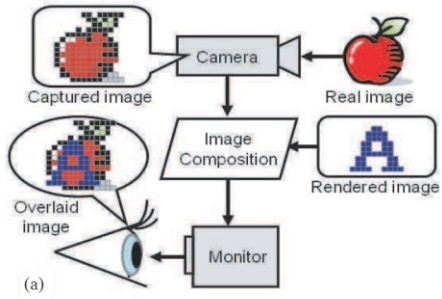


Figure 5. Surface relief slanted sub-wavelength gratings as optical combiners and exit pupil expanders.

[„Diffractive and Holographic Optics as Optical Combiners in Head Mounted Displays“, Bernard C. Kress]

video see-through HMD



[Haller2007]

video see-through HMD

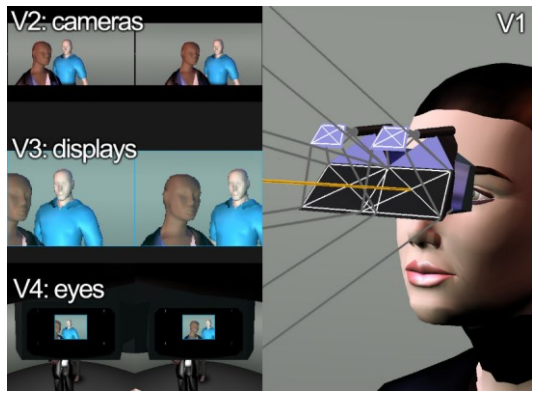
camera delivers image to display
→ no direct view of reality

Advantage: real image can be manipulated, too!

Disadvantage: time lag, parallax between eye and camera view point

But parallax-free design possible! →

parallax-free video see-through HMD

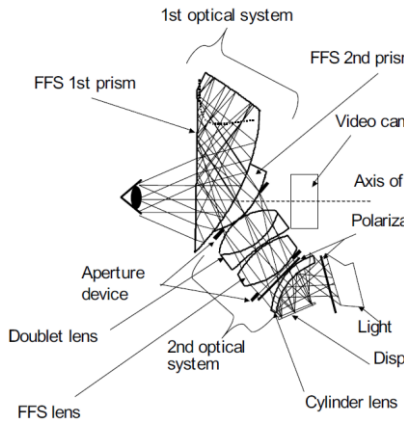


optics are designed so that the (reflected) camera viewpoint is in the users pupil

video:

[State2005]

parallax-free video see-through HMD



[Inoguchi2008]

free – form prisms allow for an extremely compact construction

Older Commercial HMDs

datavisor
(nvision)

ST40 (Kaiser)

i-glasses

Addvisor (SAAB)

glasstron (Sony)

Commercial HMDs

HTC Vive Pro

Oculus Rift

Pimax 8k

Meta2

Sony HMZ-T2

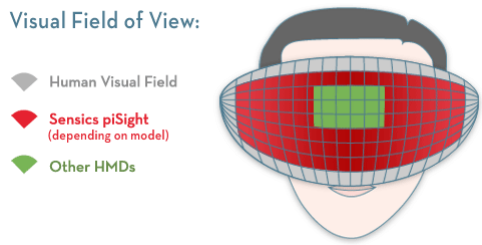
Commercial HMDs: Panoramic HMD

www.Sensics.com
claims:

- Panoramic field of view: from 82° to 180° diagonal
- A modular, upgradeable design
- High resolution: Up to 4200x2400 pixels per eye (2400x1720 effective)
- Ease of use: weighing less than 1 kg (2 lbs.), open-frame design: comfortable and stays cool

Commercial HMDs: Panoramic HMD

the field of view is considerable larger than other HMDs':



delivering a better sense of immersion

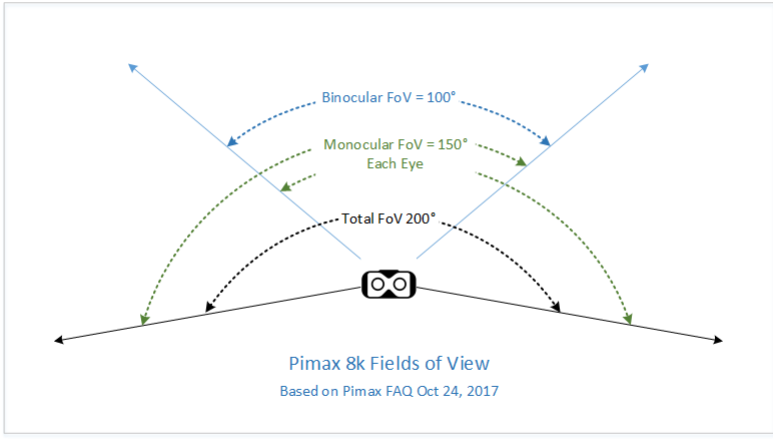
Commercial HMDs: Panoramic HMD

The wide field of view is made possible by using not one LCD but several, which in combination with special optics tile seamlessly:

Commercial HMDs: Pimax 8k HMD

Just two displays at an angle:

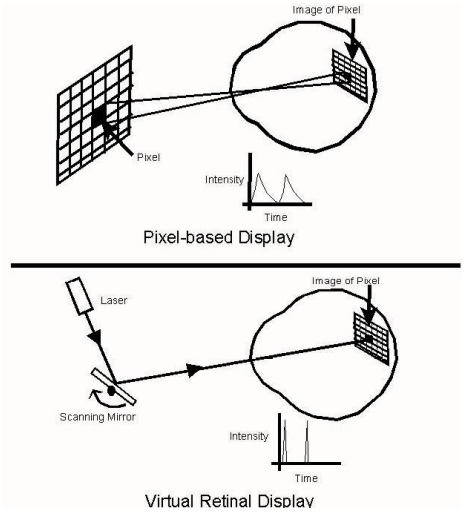
Commercial HMDs: Pimax 8k HMD



Retinal HMD

image exists on display surface, is viewed by eye

image exists **only** on retina



Retinal HMD

since the laser beam is extremely thin, even tiny particles throw shadows on the retina

“eye floaters”:

http://en.wikipedia.org/wiki/Floater

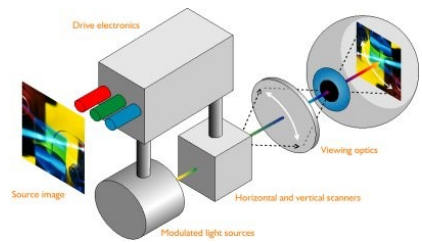
Retinal HMD (NOMAD, Microvision)

uses laser to directly project on users retina

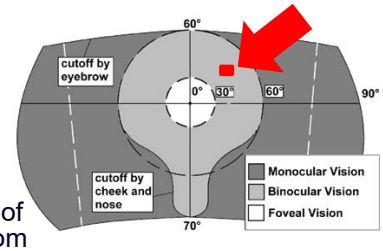
Advantages: bright, always focussed, see-through

Disadvantages: monchrome (red) 32 shades

very sensitive to impurities in the eye!



Google Glass



Preliminary specs:

Display

High resolution display is the equivalent of a 25 inch (64cm) high definition screen from 8 feet (2.4m) away (≈15° diagonal)

Camera

Photos - 5 MP

Videos - 720p

Audio

Bone Conduction Transducer

Connectivity

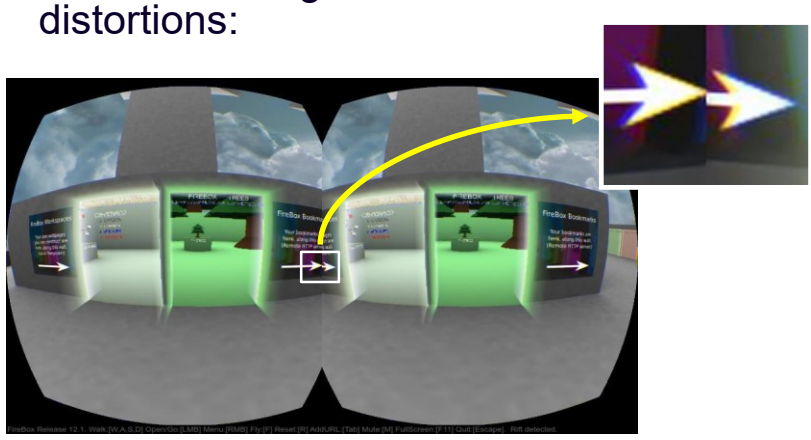
Wifi - 802.11b/g

Bluetooth

Oculus Rift

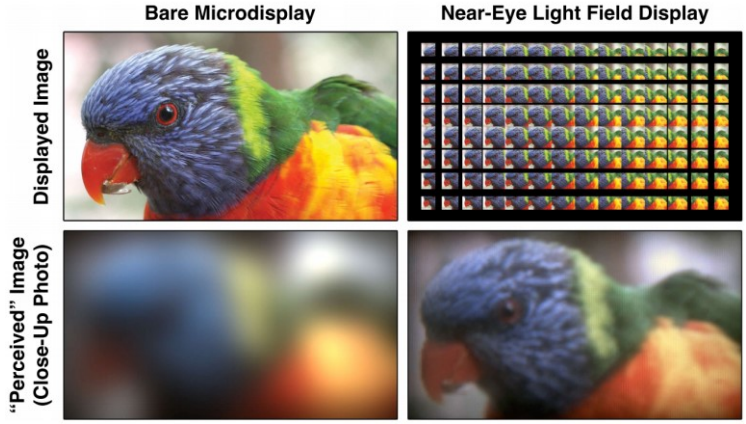
Oculus Rift

shader corrects geometric & chromatic distortions:



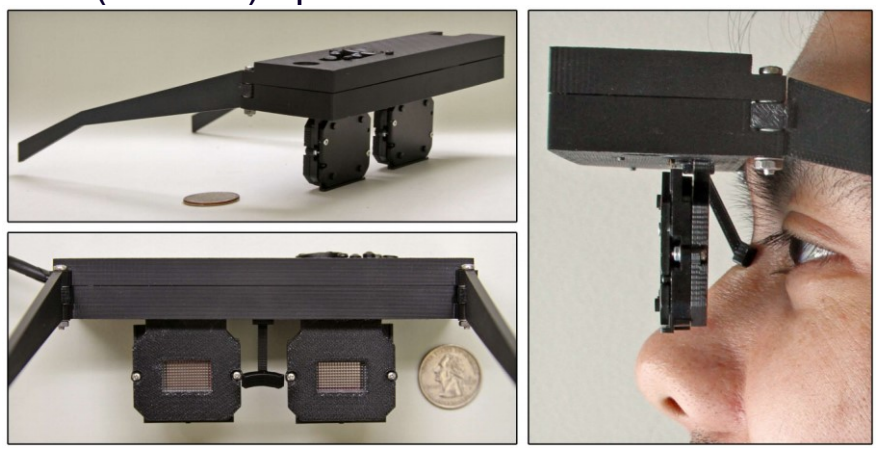
Light Fields HMD

Micro lenses in front of segmented views:



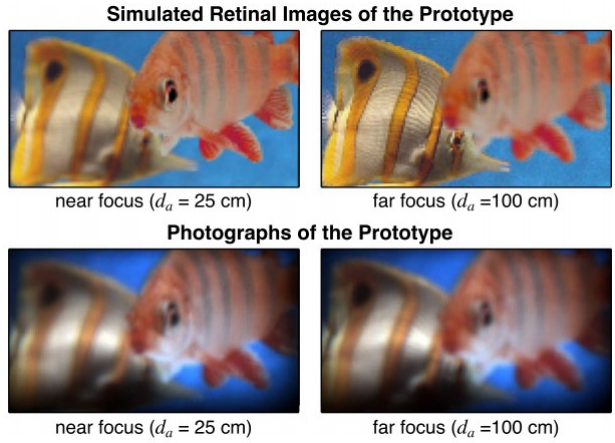
Light Fields HMD

Flat (~10mm) optical element:



Light Fields HMD

Depth of Field:



Light Fields HMD (video)

Light Fields HMD

Advantages:

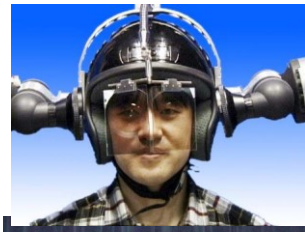
- depth-of-field
- thin optics

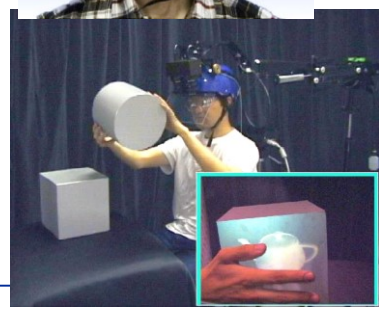
Disadvantages:

- reduced resolution

"Near-Eye Light Field Displays"
Douglas Lanman (NVIDIA), David Luebke (NVIDIA), in *ACM Transactions on Graphics (TOG), Volume 32 Issue 6, November 2013 (Proceedings of SIGGRAPH Asia)*, November 2013

Head-Mounted Projectors

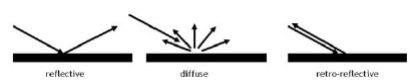




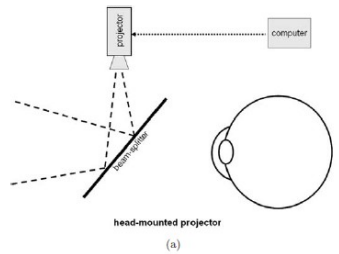
uses projector to display from users viewpoint on (retro-reflective) environment

Advantages: „correct“ occlusion

Disadvantages: heavy, varying focus distance, stereo separation depends on retro-reflection quality



Head-Mounted Projectors



(a)

simplified head-mounted projector set-up


(b)


(c)

example prototypes
(note „glowing eyes“)

[Furht2011]

head attached display: VR telescope

Consists of a video camera and monitor

Very rugged, immediately usable by untrained users

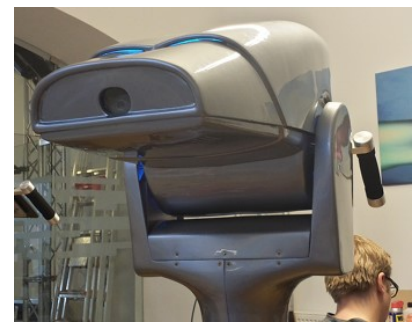
→*mechanical tracking* in the joint allows easy video augmentation (precise & fast rotation sensor)

https://www.igd.fraunhofer.de/en/Institut/Abteilungen/VRAR/Projekte/AR-Telescope

head attached display: zacturn 2.0

comparable to “VR telescope”:

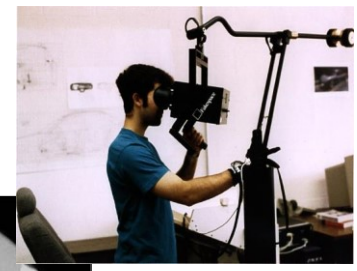
Austrian development: www.zkoor.at

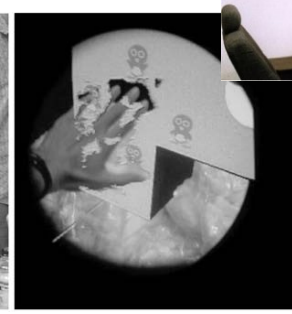


head attached display: zacturn 2.0

head attached display: Boom

Fakespace boom





Hand-held Displays

Tablet PCs

smartphones

essentially the same as video HMDs

contain enough sensors for many AR applications:

GPS

compass

acceleration

camera(s)

Marker-based AR: ARToolkit

ARToolkit 1999!

uses simple geometric markers for tracking

HMD/display calibration
video see-through

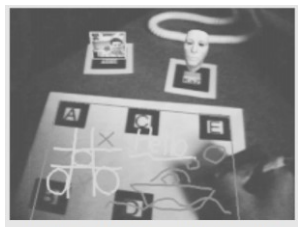
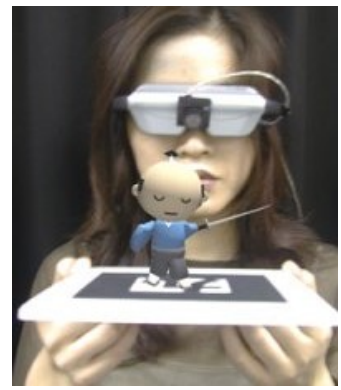


Figure 4. Virtual Shared White Board.



Kato, H., Billinghurst, M. (1999) Marker Tracking and HMD Calibration for a video-based Augmented Reality Conferencing System. In Proceedings of the 2nd International Workshop on Augmented Reality (IWAR 99). October, San Francisco, USA.

Hand-held AR

lots of AR toolkits for phones/tablets:

- Vuforia
- Wikitude
- LayAR
- ARCore (Google/Android)
- ARKit (Apple/iOS)