Special Topics in Virtual Reality

Display Devices 1/2

http://tinyurl.com/STVR2019

Display Devices

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

„Exotic Displays“
- Volumetric Displays
Classification of stereoscopic displays

### 2D Displays
- Based-3D imaging
  - 2D-SI

### Mediated Stereoscopic Imaging
- (MSI)

### Auto-stereoscopic Imaging
- (ASI)

### Pseudo-volumetric Stereoscopic Imaging
- (PVSI)

### Fully Volumetric Stereoscopic Imaging
- (FVSI)

### Augmented Volumetric Stereoscopic Imaging
- (AVSI)

####Examples of display devices/technologies
- Cathode ray tubes
- Liquid crystal displays (LCD)
- Plasma panel
- Wall projection systems
- Digital light processing (DLP) displays
- Storage tube
- Field emission displays (FED)
- Liquid crystal on silicon (LCOS)

####Category of technology
- Color multiplexed
- Polarization multiplexed
- Time multiplexed shutter
- Location multiplexed HMD
- Bivocal omniorientation monior
- CAVE/VR systems

- Direction multiplexed
- Grating-based diffractive
- Holographic optics-based diffractive
- Integral imaging
- Lenslet refractive
- Accommodation compensated
- Electro-holographic
- Infra-red activated fluorescent gas dome
- Rotating LED panel-based
- Revolving double helix-based display devices

- Multi-planar projection based volumetric imaging
- Translucent depth plane controlled display devices
- Augmentable holograms


Anton L. Fuhrmann
Advanced Topics in VR
2019
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

- 1960 Heilig
- 1963 Hall, Miller
Head-Mounted Display History

• The “Sword of Damocles”

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

• ultrasound & mechanical tracking

• CRT see-through display


see also:
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)

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**optical see-through HMD**

![Diagram of optical see-through HMD](image_url)

other optical configurations

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

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

http://doi.acm.org/10.1145/2601097.2601141
**pinlight see-through HMD**


**diffractive see-through HMD**

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

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

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

[Haller2007]
parallax-free video see-through HMD

Optics are designed so that the (reflected) camera viewpoint is in the user's pupil.

[State2005]

parallax-free video see-through HMD

Free-form prisms allow for an extremely compact construction.

[Inoguchi2008]
Older Commercial HMDs

- datavisor (nvision)
- ST40 (Kaiser)
- Addvisor (SAAB)
- i-glasses
- 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

the field of view is considerably 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:

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Commercial HMDs: Pimax 8k HMD

Just two displays at an angle:
Commercial HMDs: Pimax 8k HMD

Pimax 8k Fields of View
Based on Pimax FAQ Oct 24, 2017

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: monochrome (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

shader corrects geometric & chromatic distortions:
Light Fields HMD

Micro lenses in front of segmented views:

- Bare Microdisplay
- Near-Eye Light Field Display

“Perceived” Image (Close-Up Photo)

Light Fields HMD

Flat (~10mm) optical element:
Light Fields HMD

Depth of Field:

Simulated Retinal Images of the Prototype

near focus ($d_f = 25$ cm)  far focus ($d_f = 100$ cm)

Photographs of the Prototype

near focus ($d_f = 25$ cm)  far focus ($d_f = 100$ cm)

Light Fields HMD (video)

Near-Eye Light Field Displays

Douglas Lanman    David Luebke
NVIDIA Research

NVIDIA
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

simplified head-mounted projector set-up

example prototypes (note „glowing eyes“)

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)

head attached display: zacturn 2.0

comparable to “VR telescope”:

Austrian development: www.zkoor.at
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

Hand-held AR

lots of AR toolkits for phones/tablets:

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