

3D Light Field

Displaying, Formats, End-to-end Systems

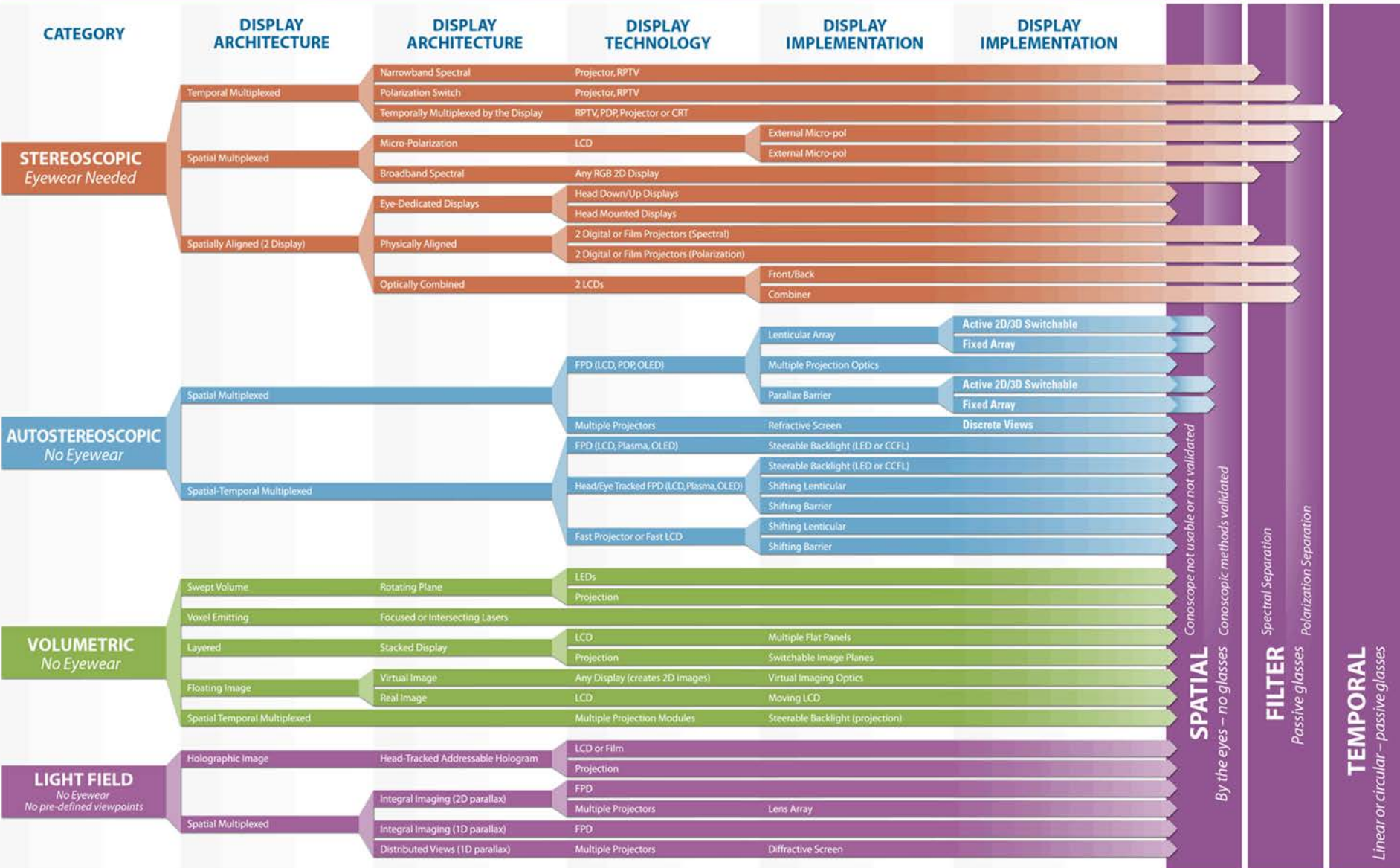
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www.holografika.com

NEM Summit
New Visual Media Formats
Zagreb, 2019. 05. 23.

3D Display Technology Family Tree

Display Options or Technology

Image Separation at Eyes



Conoscope not usable or not validated

Conoscopic methods validated

Spectral Separation

Polarization Separation

SPATIAL
By the eyes - no glasses

FILTER
Passive glasses

TEMPORAL
Linear or circular - passive glasses

Light Field Displays

– small etymology

- Plenoptic
(Latin *plenus* (“full”) + *optic*, relating to all the light, travelling in every direction, in a given space)
- Holoscopic
- Automultisopic
- Supermultiview
- Field-of-Light (marketing...)

* Integral imaging, holography - sampled wavefront

3D Light Field

- a candidate for next generation 3D systems

- 3D image contains more information than a corresponding 2D
 - more pixels or higher speed components, or combination of both
- For real 3D this is ~ **100x** – a real technology challenge
 - for holographic systems this would be in the range of $\times 10^7$
- If not there, will compromise the capability of any 3D system

"Display is the last frontier. Over the years, processing power has improved and networks have more bandwidth, but what is missing is comparable advancement in display."

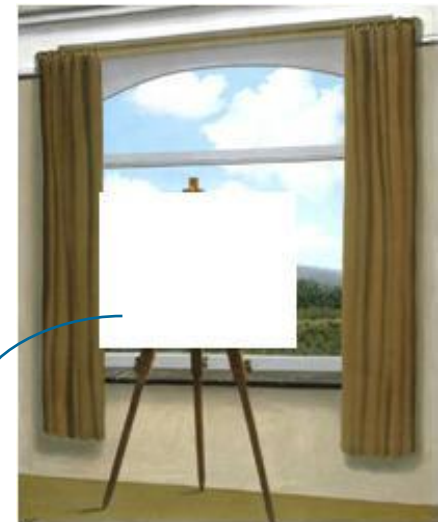
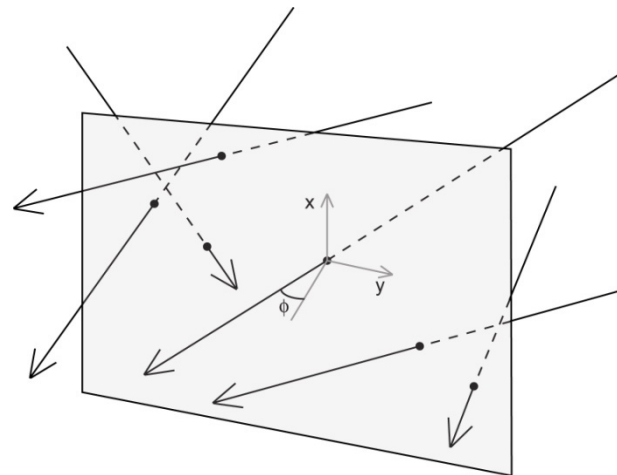
3D Light Field

- Real 3D displaying - reconstructing the **light field** as present in the natural view
 - producing light beams with the same parameters the human perception is capable to process: direction, position, intensity, color (*polarization, phase*)



3D Light Field

- General representation of 3D information that considers a 3D scene as the collection of light rays that are emitted or reflected from 3D scene points
 - the visible light beams are described with respect to a reference surface (screen) using the light beams' intersection with the surface and angle, or position on two planes
 - the LF is defined as a function of position (2(3) parameters) and direction (2 parameters): $L(x,y,[z],\Theta,\Phi)$
 - plenoptic function (7-D function $P(\theta, \varphi, \lambda, t, V_x, V_y, V_z)$)

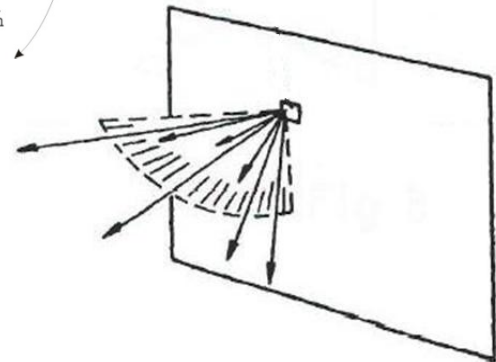
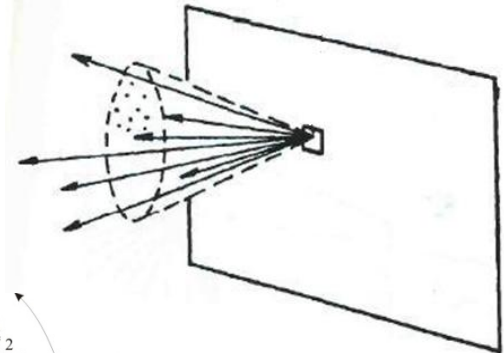
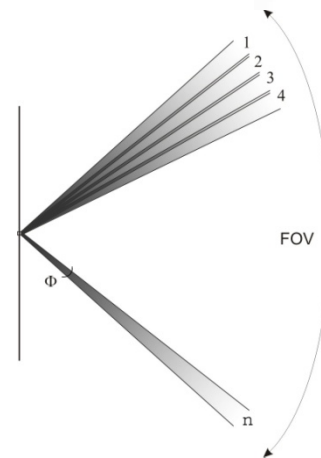


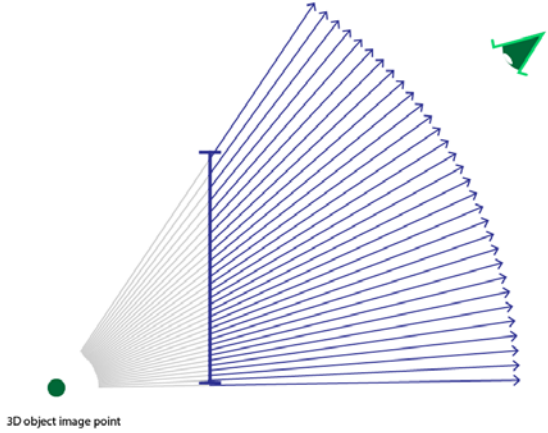
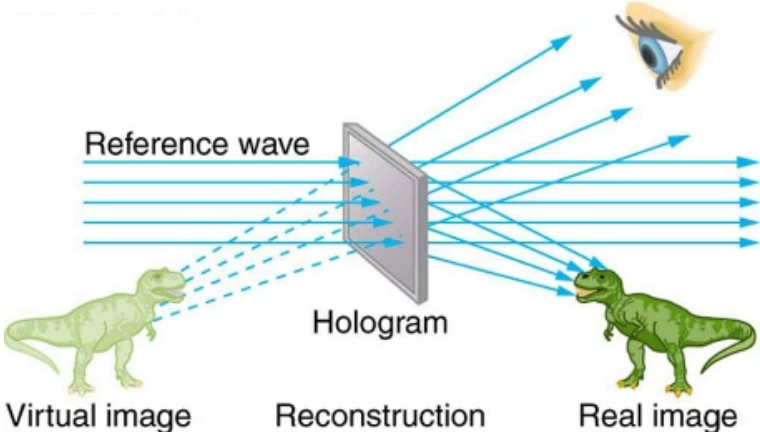
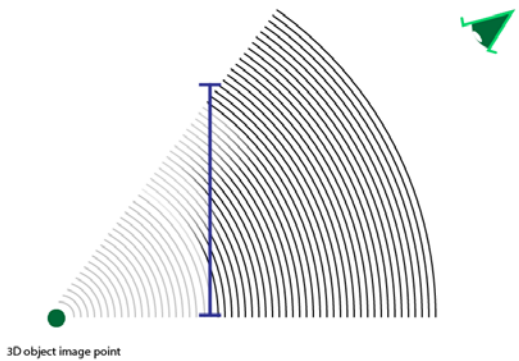
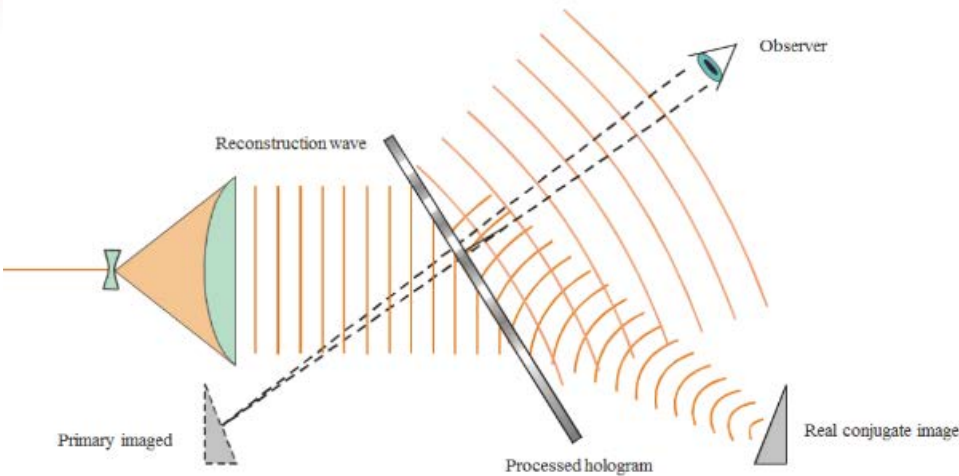
3D Light Field

- Additional independent variant to x, y : ϕ
 - emission range - FOV
 - number of independent beams in the range – Angular resolution (ϕ) determining FOD

$$\text{FOV} / n = \phi$$

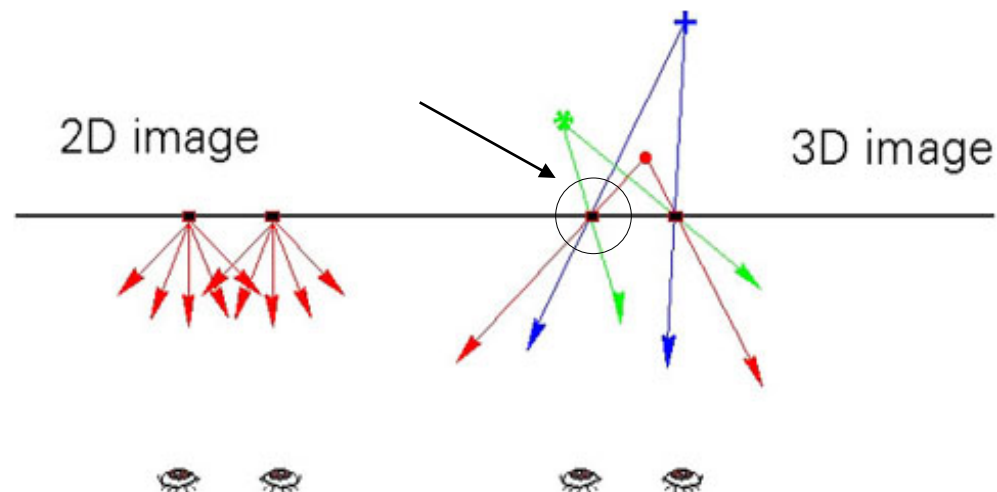
- Vertical / horizontal parallax
 - reducing the number of beams by omitting the vertical parallax
 - HOP systems





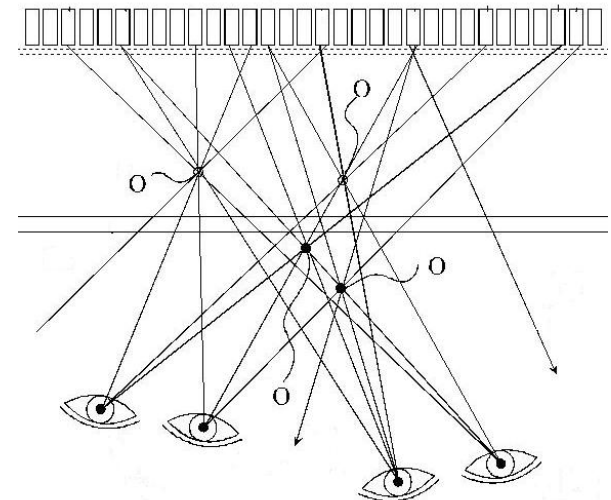
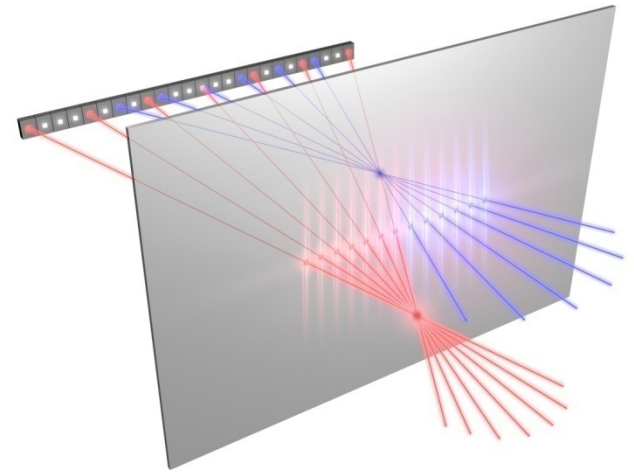
3D Light Field

- Direction selective light emission
 - common for all systems having a screen, (also for the outer surface of volumetric systems)
 - 3D displays always have some optical means
- General approach: to create a light emitting surface to emit different light beams from each point in a controlled way - defining the output



3D LF HoloVizio System

- Light field reconstruction instead of views, specific distributed image organization
 - the projected module image is not a 2D view of the final 3D image
 - each view of the 3D image comes from more projection modules
 - continuous motion parallax - no discrete border between views



HoloVizio Displays

HOLOVIZIO™ 80WLT

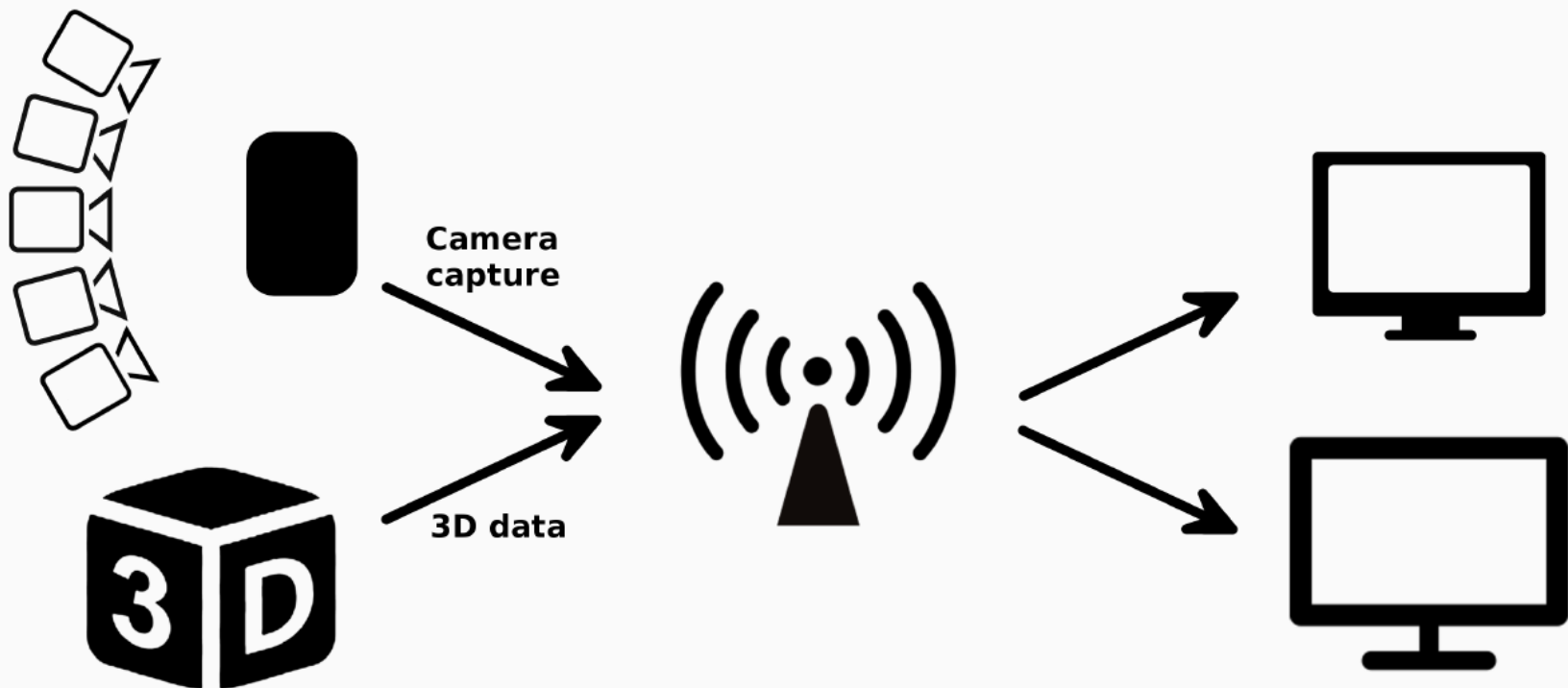
**Full-angle
3D Displaying**

Large-scale HoloVizio Systems

- HV C80 Glasses-free 3D Cinema



3D LF Formats



3D LF Formats

- Input data
 - Inherently 3D data
 - 3D geometry + metadata („Textured meshes”, Point Cloud)
 - Volumetric data
 - Inherently 2D data
 - Camera image set
 - Generated metadata types
 - Per camera pixel depth map
 - Per camera pixel disparity map
 - Per display optical modul pixel disparity map
 - Per display optical modul pixel depth map
- Light field formats
 - 3D geometry + metadata formats („Textured meshes”, Point Cloud, e.g. .ply, .obj, .fbx, .max, etc.)
 - Separate compressed video streams
 - *Composite image compressed with separately decompressable macroblocks*
 - MPEG MVC
 - Video + disparity streams
 - Video + depth streams (MVD)
 - JPEG Pleno
 - MPEG-I, LF ahg
 - Plenoptic camera formats (e.g. former Lytro .lfp)
 - ORBX (container format for VR - Otoy)

3D LF Formats

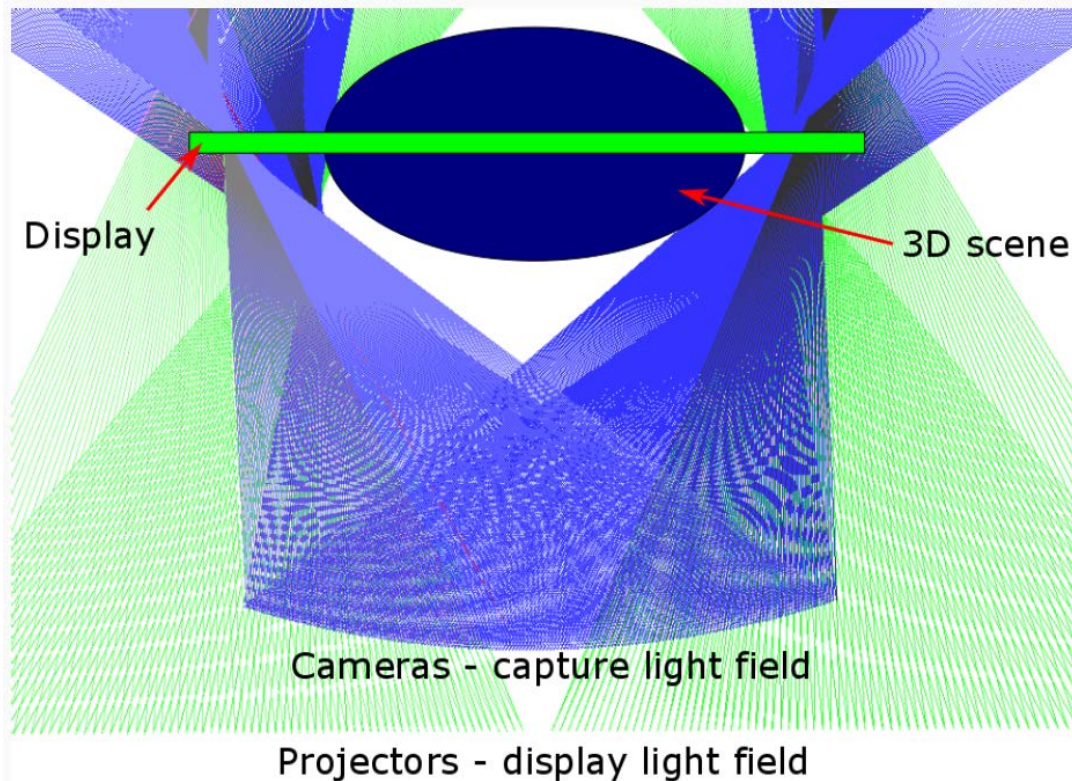
- Use cases – time, quality, bandwidth, latency, computing power requirements

Capture → Network / Storage → Display

		LF Capture	
		Off-line	Live
LF Display	Off-line	3D cinema	Capture to cloud
	Live	Video-on demand	Telepresence

3D LF Formats

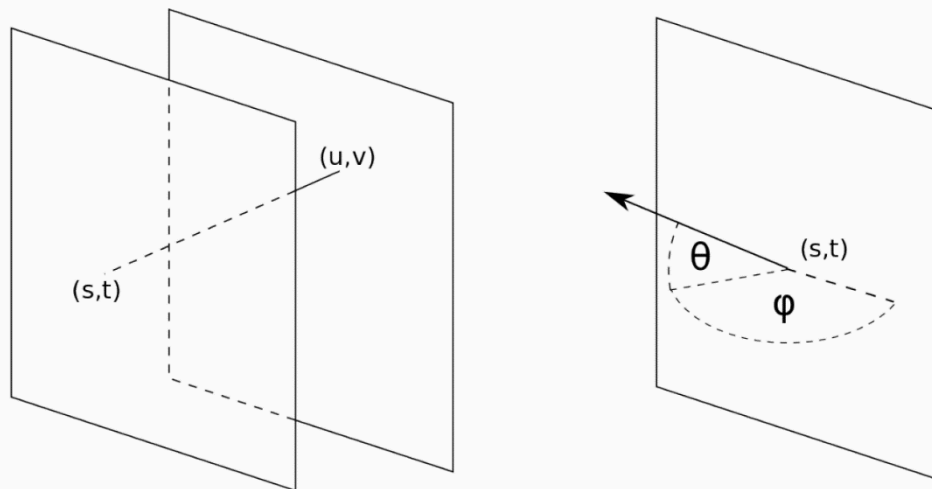
- Conversion of capture LF to display LF is expensive (especially for different type of displays)
- Mezzanine format is needed



- system specific light field structures
- LF ray sampling and interpolation

3D LF - s, t, ϕ Format

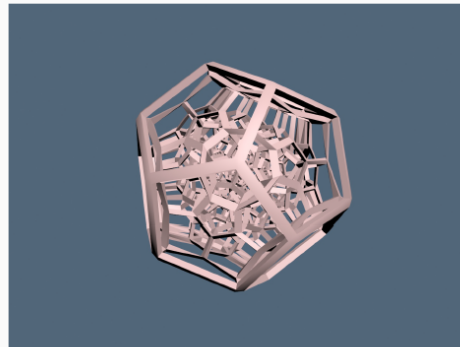
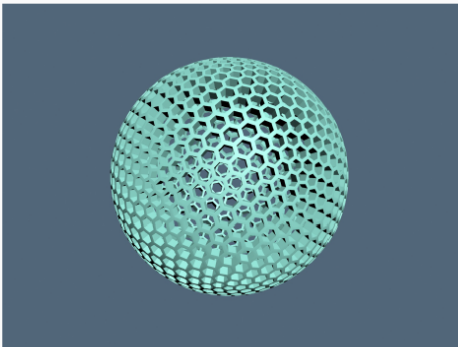
- Holografika's angularly continuous light field format (HOP)
 - Per screen pixel angular pixels
 - We define a light field image with the following 4 parameters: width, height, # of angular sections and FOV



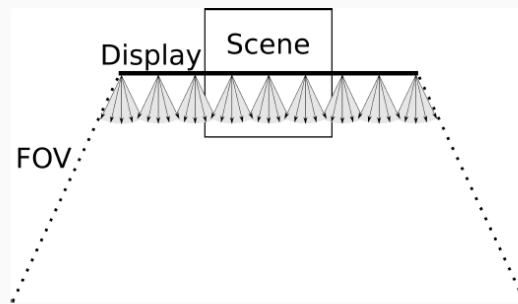
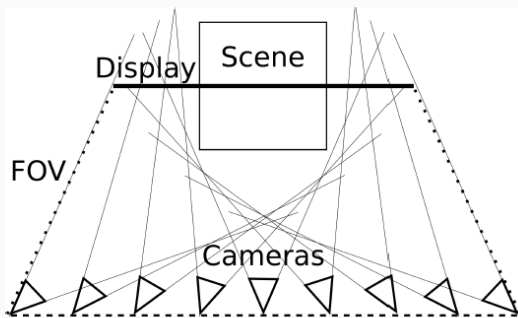
- + Display independent, mezzanine
- + fast LUT conversion
- + planar screen, any FOV
- + compatibility (for FPI: s, t, ϕ, θ)
- Resampling
- Processing on both sides

3D LF - s, t, ϕ Format

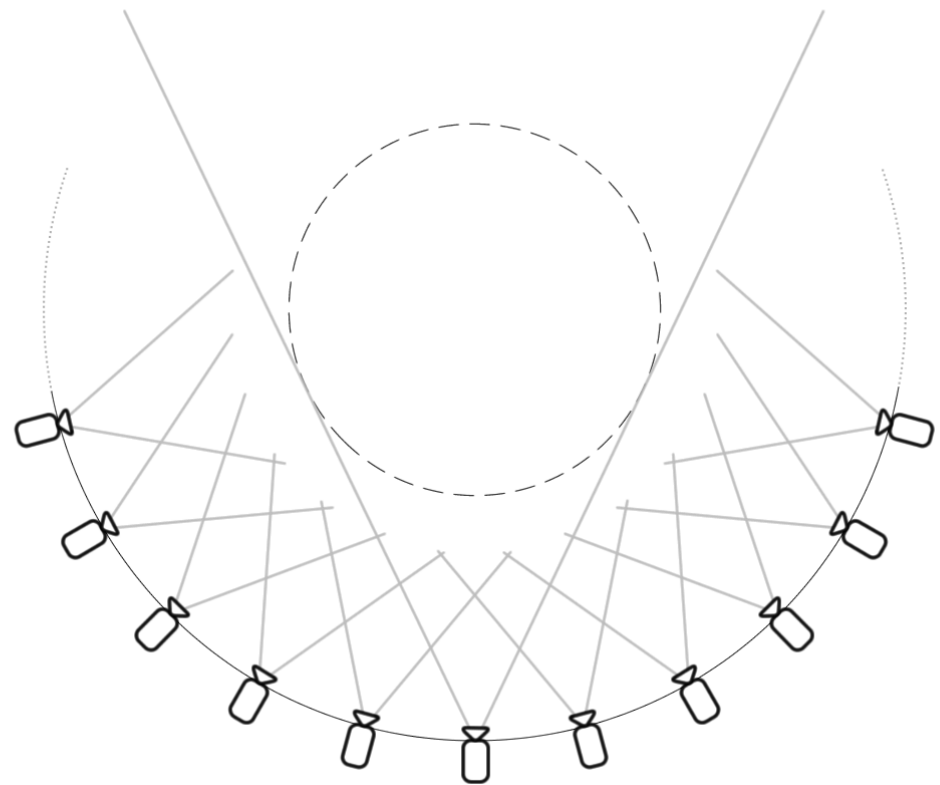
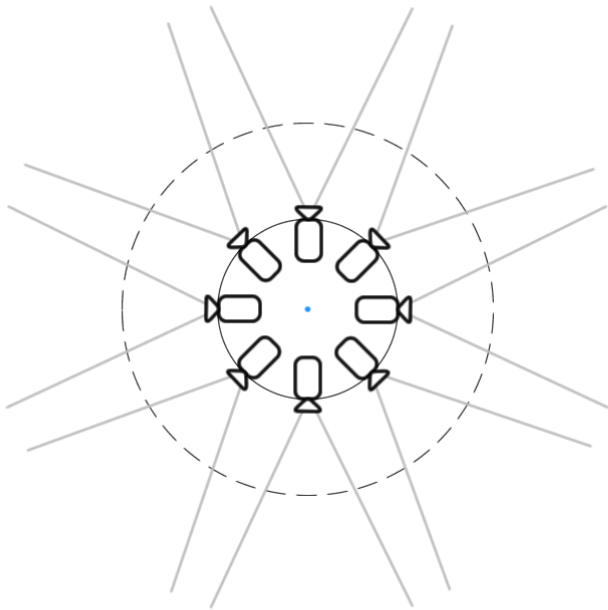
- Test: identical overall resolution, but different sampling structures



- The advantage of the novel format increases with decreasing number of pixels
- Initial expert review on test scenes say: the new format is better

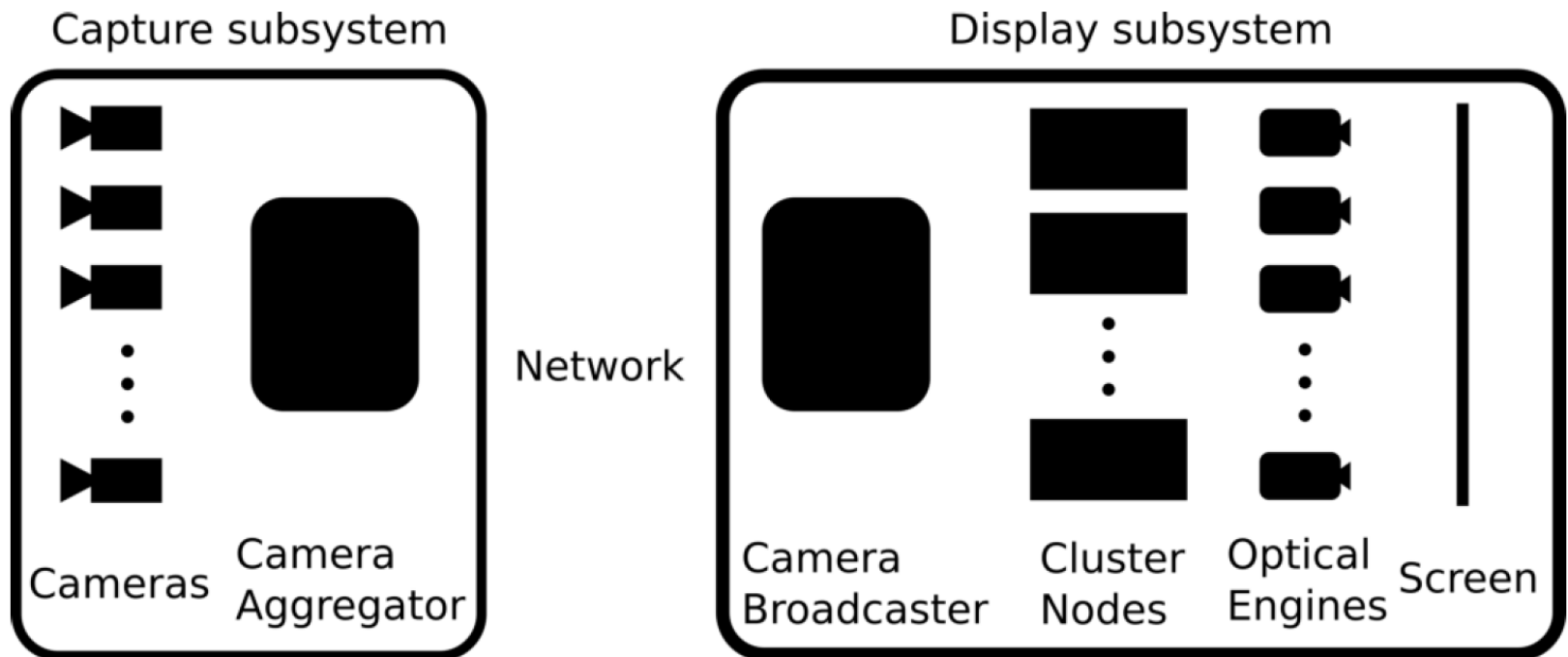


VR vs. LF geometry



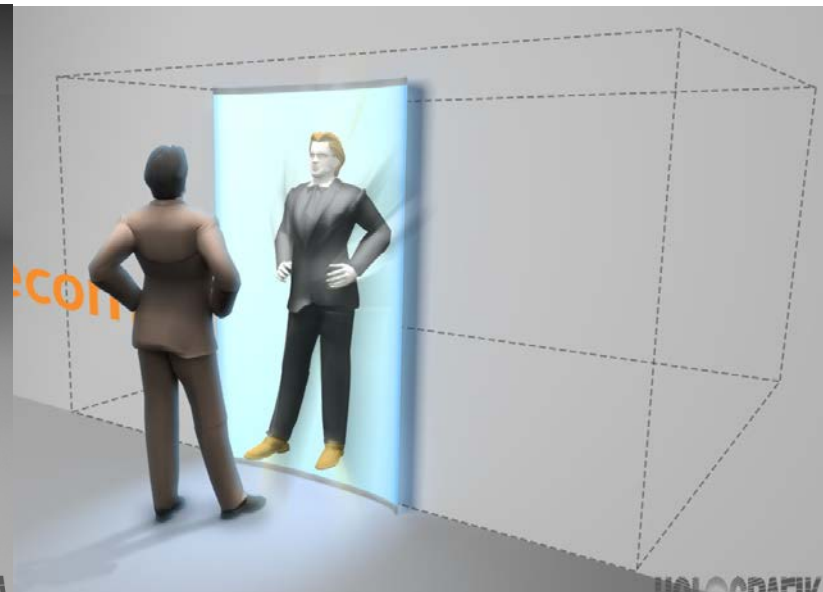
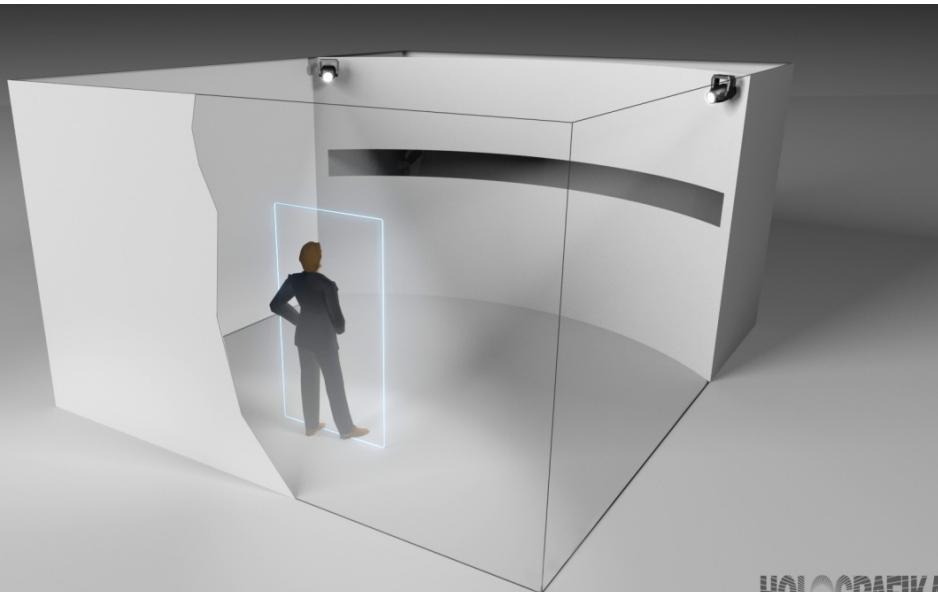
Single viewpoint vs. Free view point (FVV)

3D LF End-to-end System



3D LF Telepresence System

- Human scale, full-FOV +100Mpixels LF display and camera system connected through an optical fiber
 - fully-synchronized cameras and LF rendering
 - low latency
 - network is a high-speed optical fiber LAN to avoid compression and transmission delays



2nd-gen 3D LF Camera System

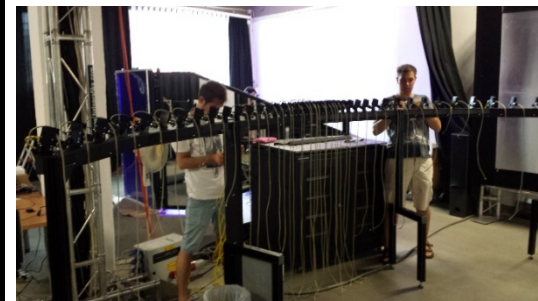
- Compact industrial GigE camera array
- Fully synchronized (hard/soft trigger)
- Arc rig, software support for arbitrary camera arrangement
 - incl. calibration, filtering unused pixels, rectification, etc.
- Real-time conversion of camera array LF to display LF
 - transmitted and stored in display independent format



- Historical shot:

3D live content
on
HoloVizio 3D display

2009



3D LF Display System

- Human-scaled screen HoloVizio display
 - 1,8 meter x 1 meter hologram screen
 - 180° full-FOV
 - +100 Mpixels, 1280 x 800 2D equivalent resolution
 - 0,9° angular resolution



3D LF Telepresence System

- Hologram Conference Room

Installed at SK Telekom Headquarter, ICT Center „T.um”, Seoul, South Korea



Hologram Conference Room

Thank you – Questions?

