최근의 3D 디스플레이 기술 및 3D/2D 변환 디스플레이 기술

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깊이 인식의 단서 (I)

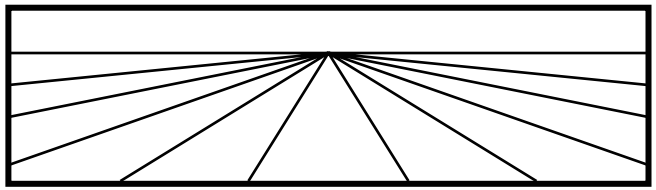
❖ **Physiological cues**

Accommodation(**초점조절**)
Convergence(**수렴**)
Binocular parallax(**양안시차**)
Motion parallax(**운동시차**)

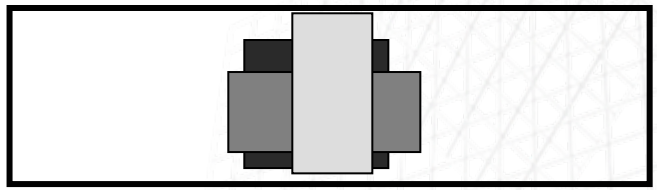
❖ **Psychological cues**

Linear perspective
Overlapping (occlusion)
Shading and shadow
Texture gradient

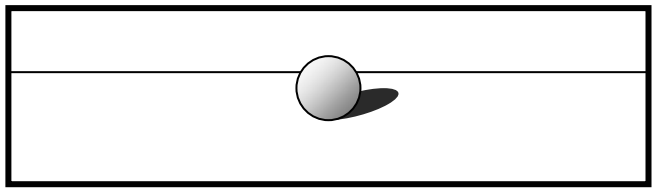
◆ **Linear perspective**



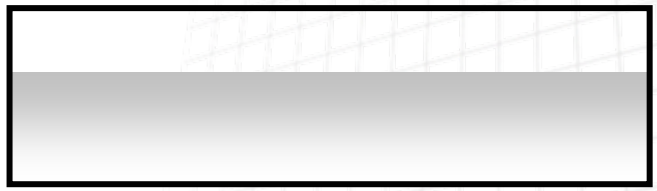
◆ **Overlapping**



◆ **Shading and shadow**



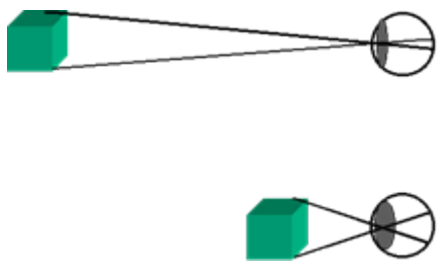
◆ **Texture gradient**



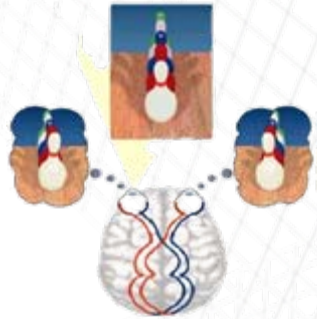
깊이 인식의 단서 (II)

❖ **Physiological cues**

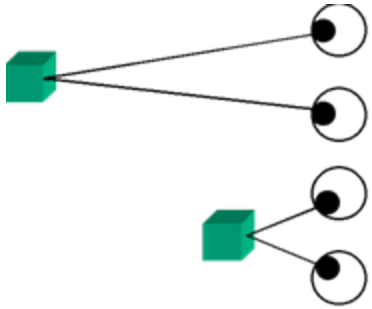
Accommodation



Binocular disparity

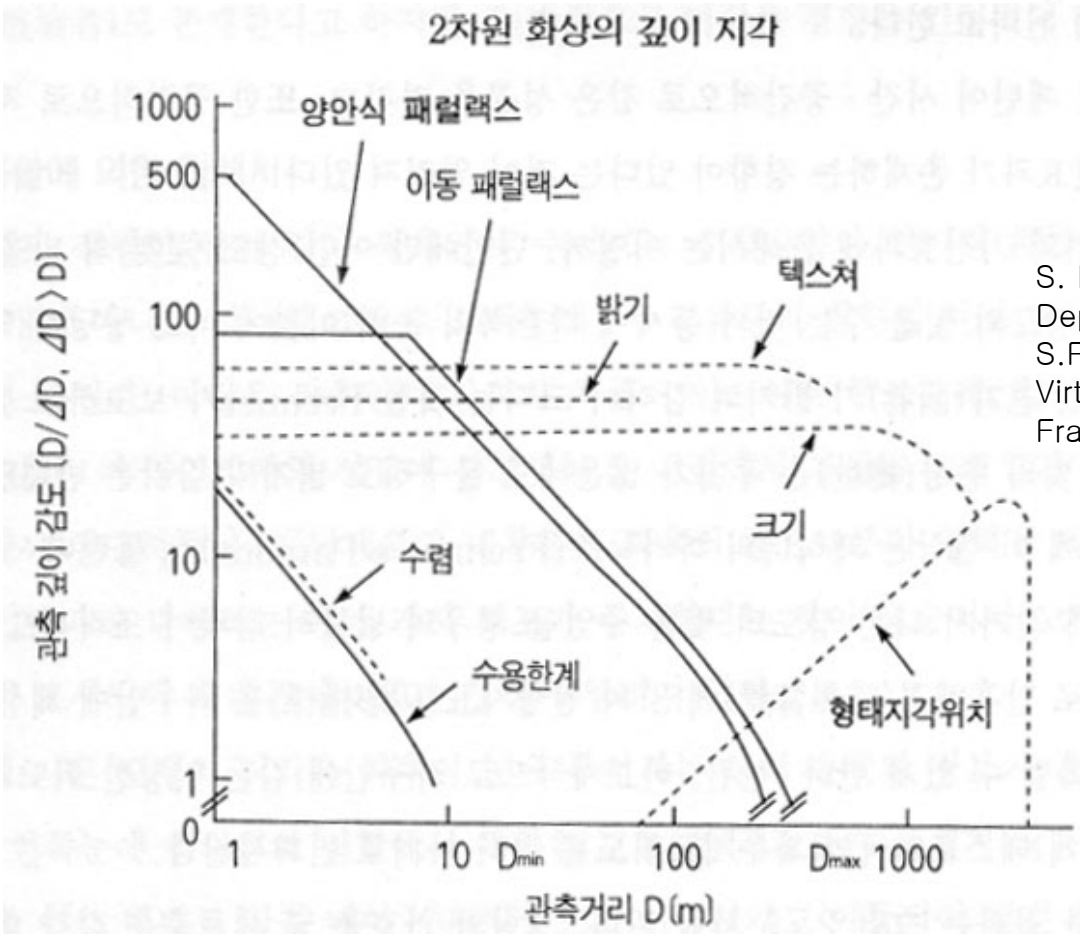


Convergence



Motion parallax

Depth Sensitivity



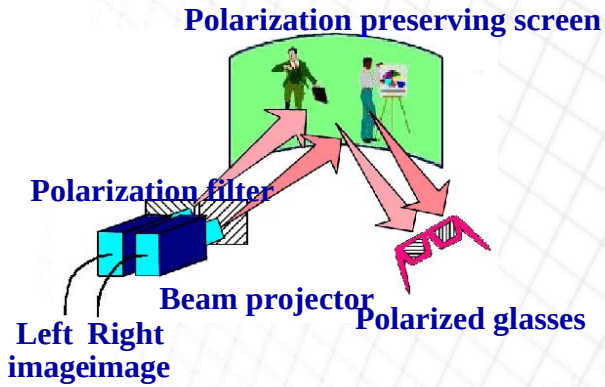
S. Nagata: How to Reinforce Perception of Depth in Single Two-dimensional Pictures., S.R. Ellis (ed.): Pictorial Communication in Virtual and Real Environments, Tyler & Francis (1991)

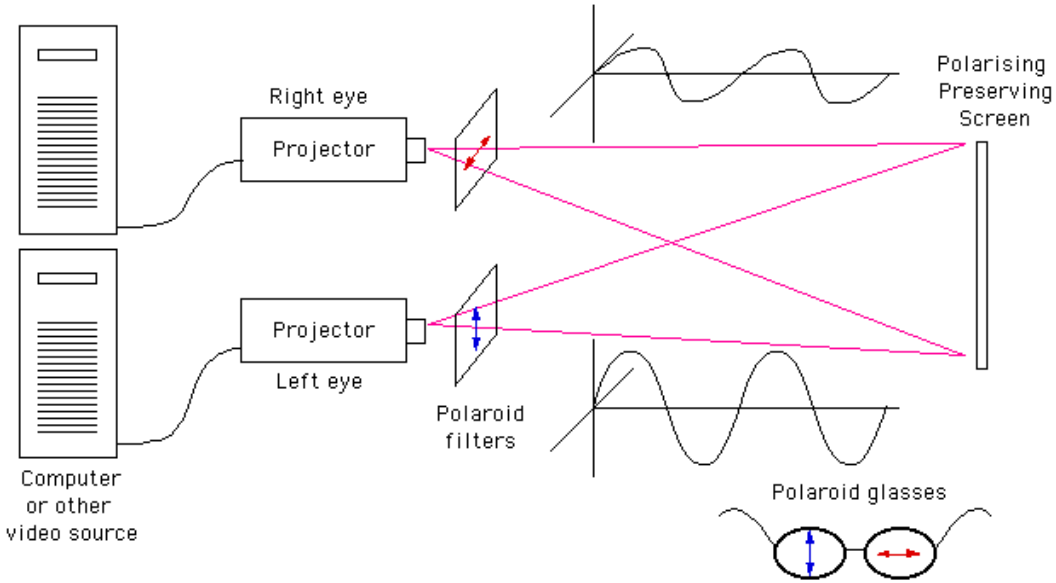
3차원 디스플레이의 구분의 예

대분류	중분류	소분류	비 고
안경식 (stereoscopy)		편광안경 방식	다인 시청 가능
		LC shutter 안경 방식	시분할 방식
무안경식	Autostereoscopy (Multi-view binocular Display)	Lenticular lens 방식	직시형, 투사형
		Parallax barrier 방식	Barrier strips
		HOE 방식	Holographic screen
		LC shutter 방식	CRT 이용
		Head tracking 방식	일인 시청
		Integral imaging	수평 수직 시차 제공, 연속시점
	Volumetric display	Varifocal mirror 방식	Vibrating mirror
		Spinning screen 방식	Mechanical motion
		Crossed-beam 방식	High cost crystal
	Holographic display	Electro-holography	동화상 가능

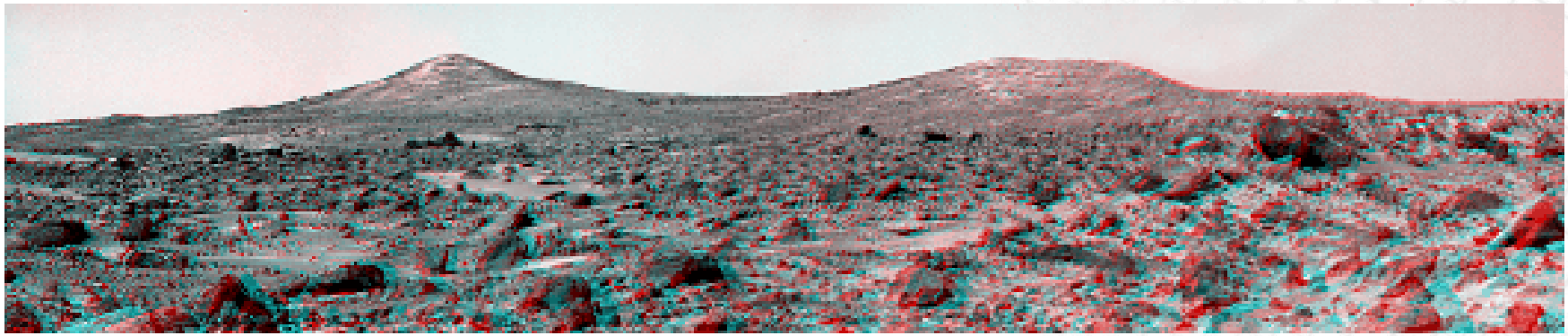
안경식 3D (Stereoscopy)

- Color multiplexed(anaglyph) display
- Polarization multiplexed display
- Time multiplexed display
- Location multiplexed display(HMD)





Anaglyph

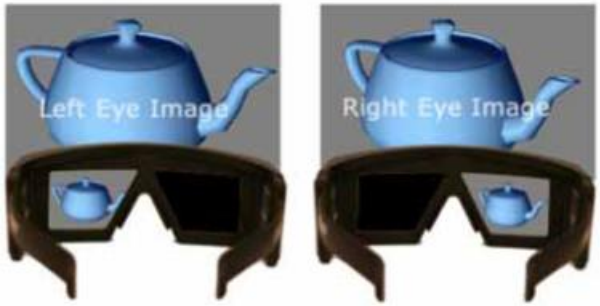


Example of anaglyph: Landscape of Mars

- **Color glasses (blue and red)**
- **The simplest method**
  - Commercialized for DVDs
- **Limitations in color expression**

LC shutter & polarizer glasses

❖ **LC shutter glasses**



Active glass

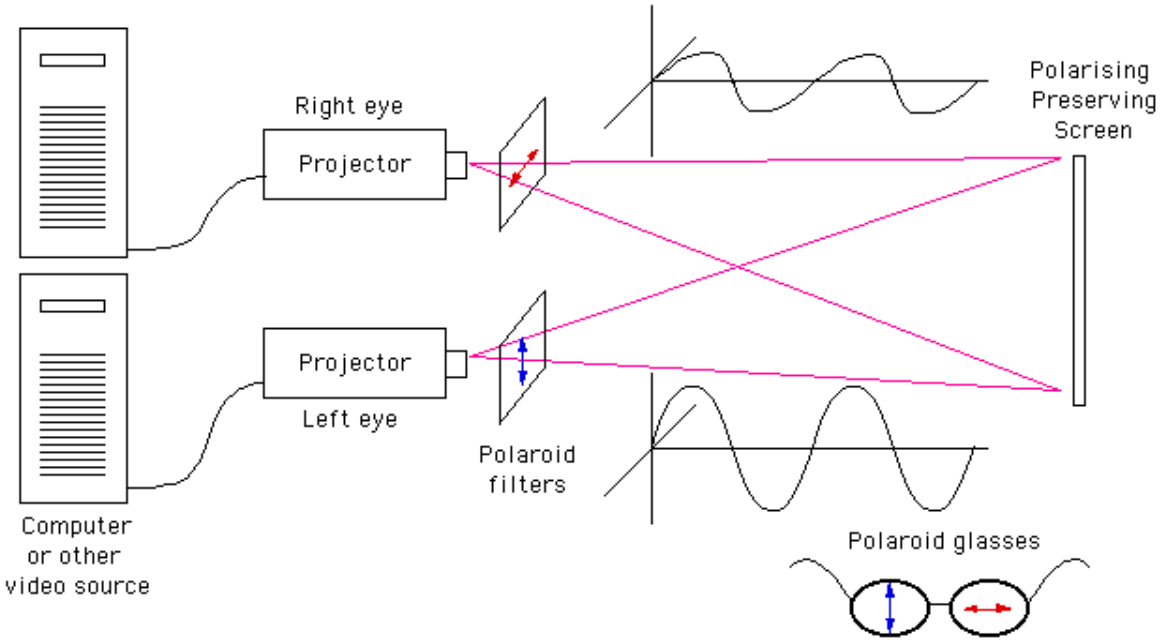
→ High price

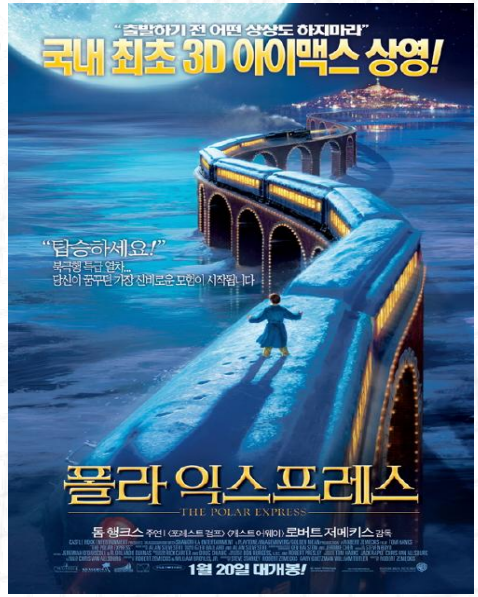
❖ **Polarizer glasses**

Polarization modulation

→ Luminance decreased

3D movies for theater (polarizer glasses)





HMD (head-mounted display)

Resolution : 266 x 255 (for DMB)

Below $250 → Cheap Price

2D / 3D 변환 가능 디스플레이의 필요성

The market of 2D display is wide.

- High-Definition (HD) broadcasting
- Mass production of Flat Panel Display (FPD) devices

  → Dropping prices

Insufficient amounts of 3D-only contents

- Limited 3D contents for entertainment purposes such as 3D theater
- No standard is established for 3D display yet.

기존 2D 시장에 3D가 들어가기 위해서는 호환성이 필수

3차원 디스플레이의 최근 기술

Autostereoscopic **방식**

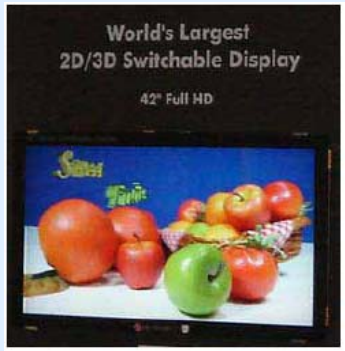
Holography

집적 영상 방식

체적형 방식과 그 외

Autostreoscopic 방식들

Parallax Barrier

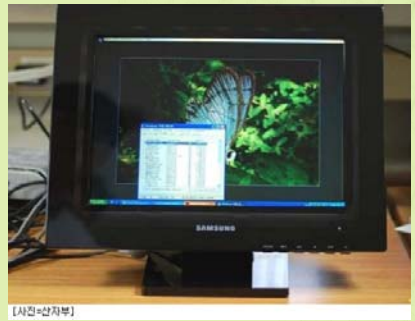


- LG Electronics/ LG.Philips LCD
- Size : 42”

Lenticular

- Philips
- Size : 42”

Field Sequential



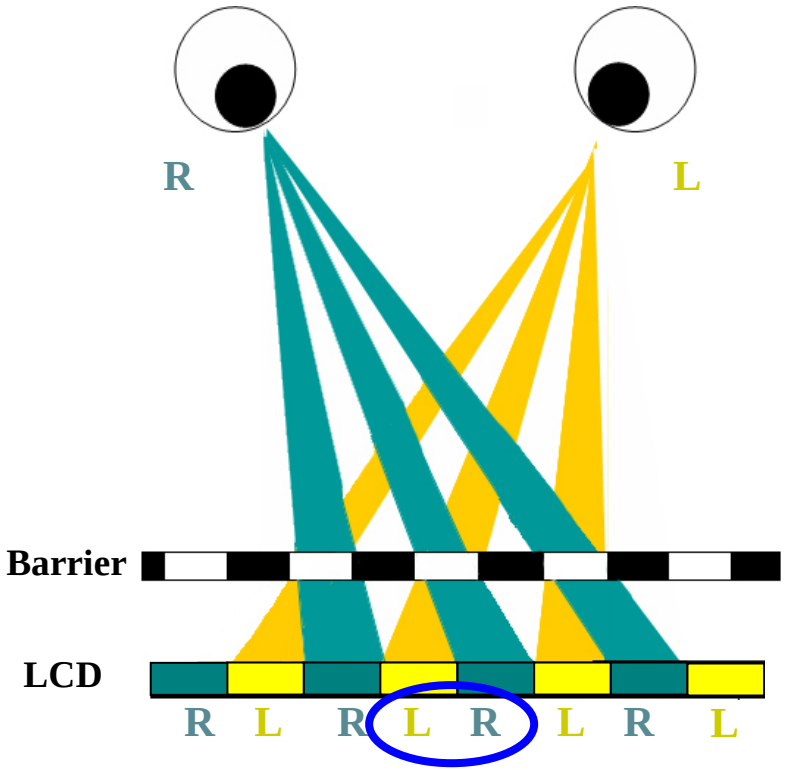
- Samsung
- Size : 17”

Integral Imaging

- Toshiba
- Size : 24”

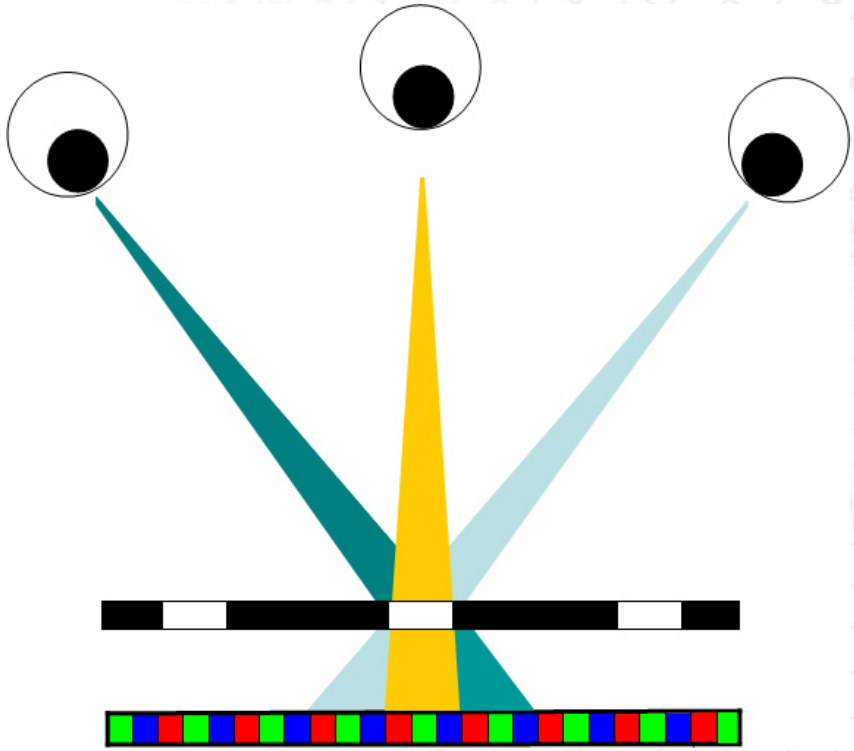
Parallax barrier

❖ **Binocular type**



Resolution & Luminance → 50%

❖ **Multi-view type**



Resolution & Luminance → 33%

Parallax barrier

- Advantages
  - 2D/3D convertible
  - Easy to fabricate (low cost)
- Disadvantages
  - Low 3D luminance
  - Moire pattern
  - Color dispersion

LG Electronics / LG.Philips LCD

❖ **Parallax Barrier Type**

Moire pattern decreased (slanted barrier)

2D/3D convertible

3D luminance decreases (55% ↓).

Items	2D mode	3D mode
Size [inch]	42	
Resolution	1920x1080	SVGA or better
Luminance	450	200
Contrast ratio	800:1	-
Viewing angle [º]	178	-
Color gamut [%]	72	-
2D/3D switching	Possible	
3D method	Parallax Barrier	
Optimum position (m)	-	4

Sharp 2D / 3D switchable display

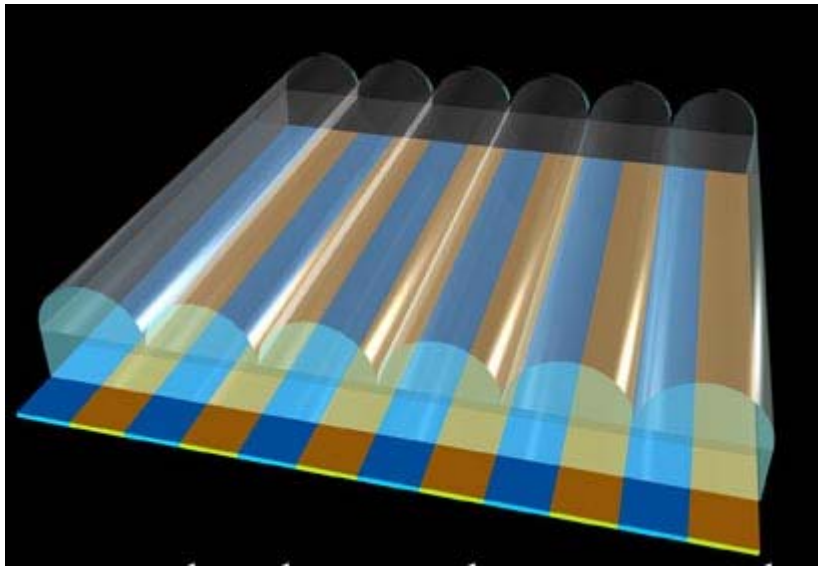
2D/3D Switchable LCD

- Autostereoscopic display
- Parallax barrier
- Image diagonal: 8 inch
- Resolution: 2D VGA

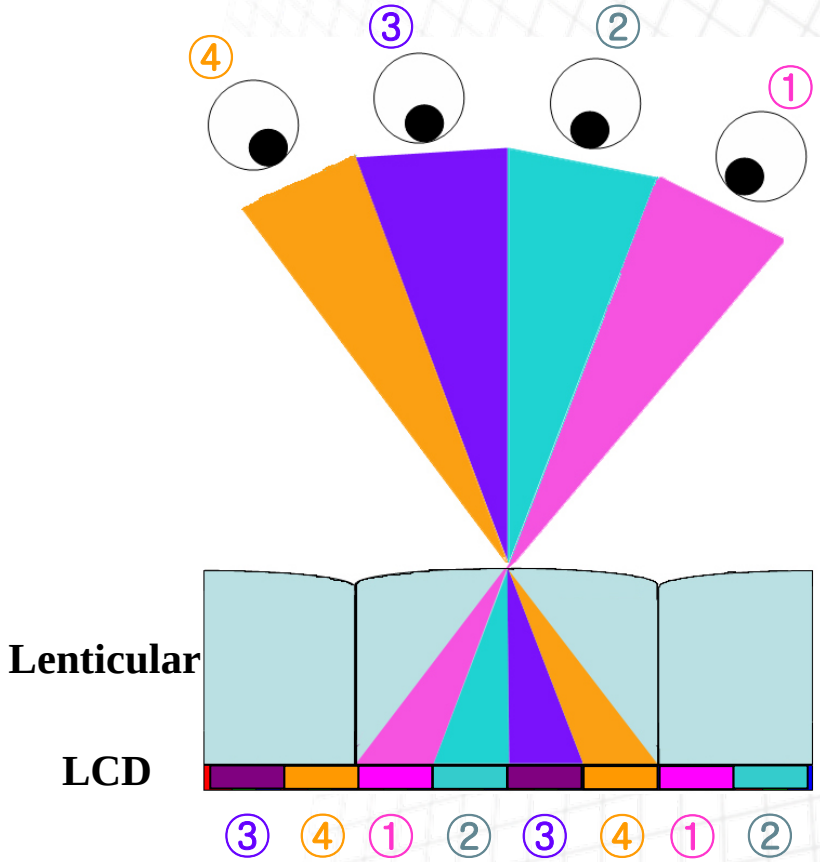
in 3D Fair 2006 (Japan)

Lenticular lens

- Lenticular Lens



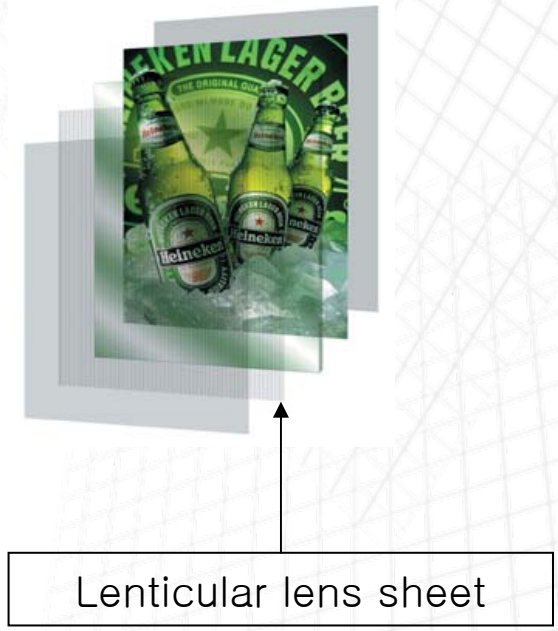
- Multi-view Lenticular



Lenticular Lens

- Advantages
  - High 3D luminance
  - Multi-view
- Disadvantages
  - Special 3D/2D conversion technique
  - Harder to fabricate (high cost)
  - Color dispersion

Lenticular Lens 방식의 예 – 3D 광고판



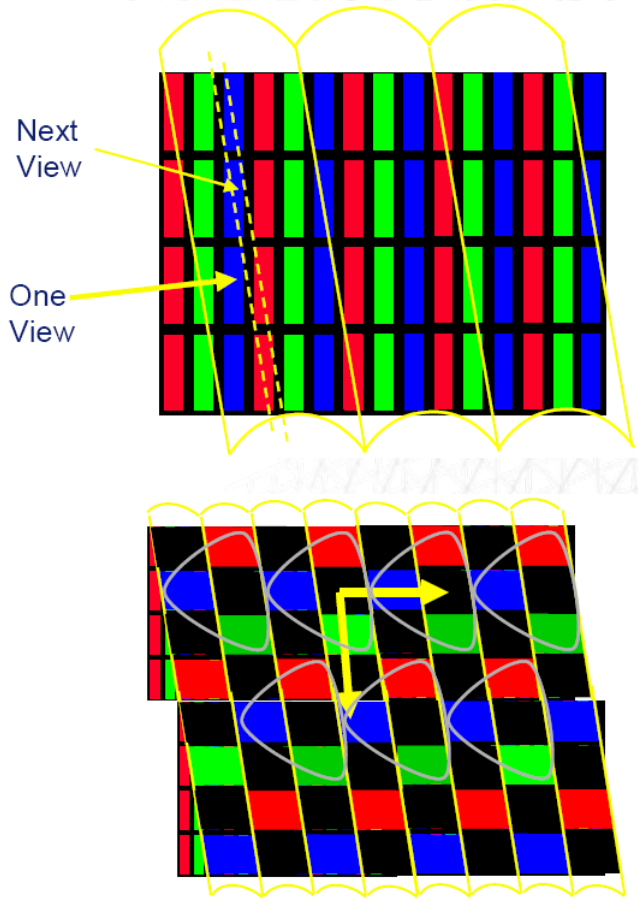
Philips

- **Slanted lenticular**

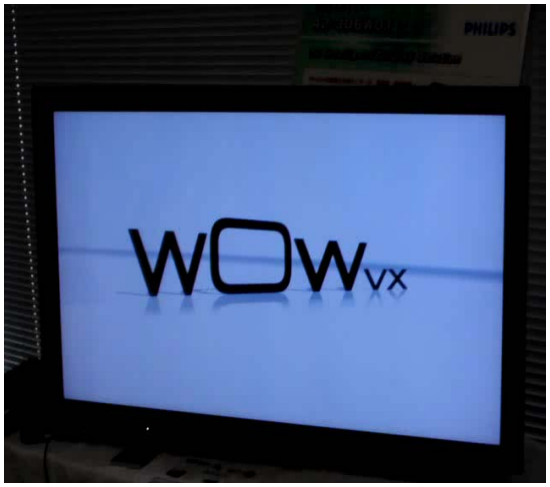
  Provides 9 views

  VGA 3D resolution

  Increased number of views (slanted lenticular)



Philips (WOW)

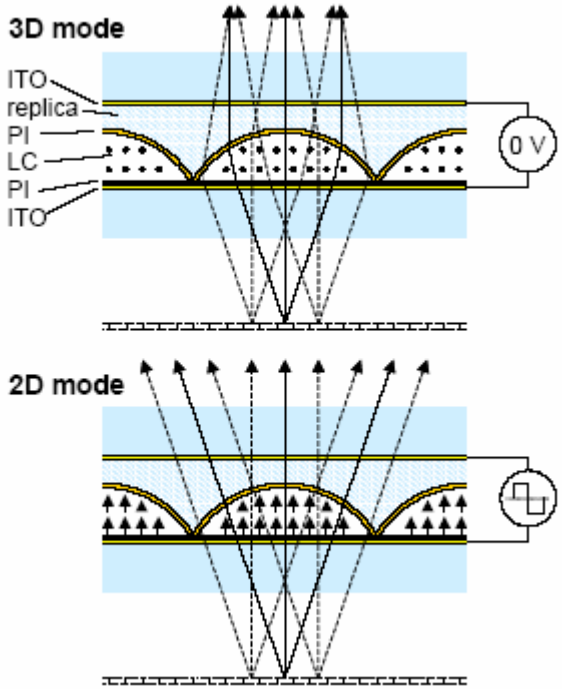


Multi-view Lenticular Display

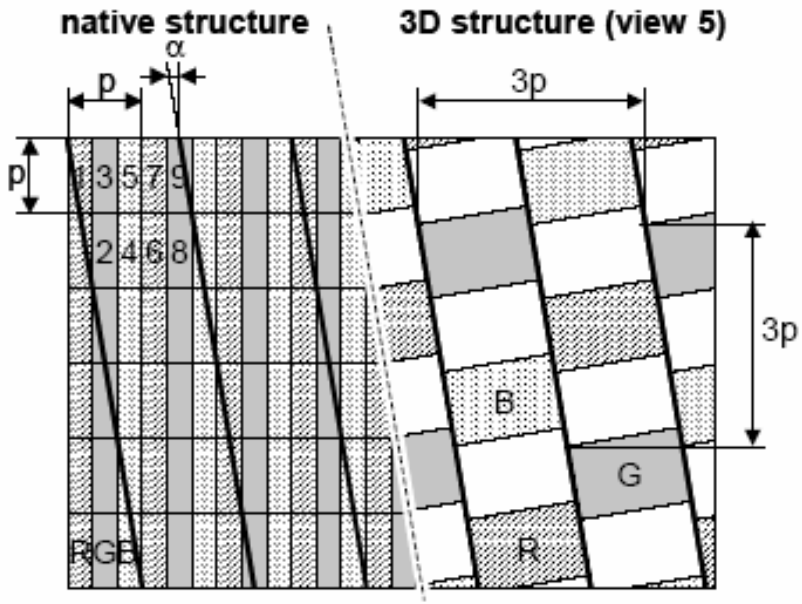
- Autostereoscopic : 9 view
- System size : 42 inch
- 2D resolution : 1,920 x 1,080
- Brightness: 460 cd/m^2

LC active lens - Philips

- Operation principle



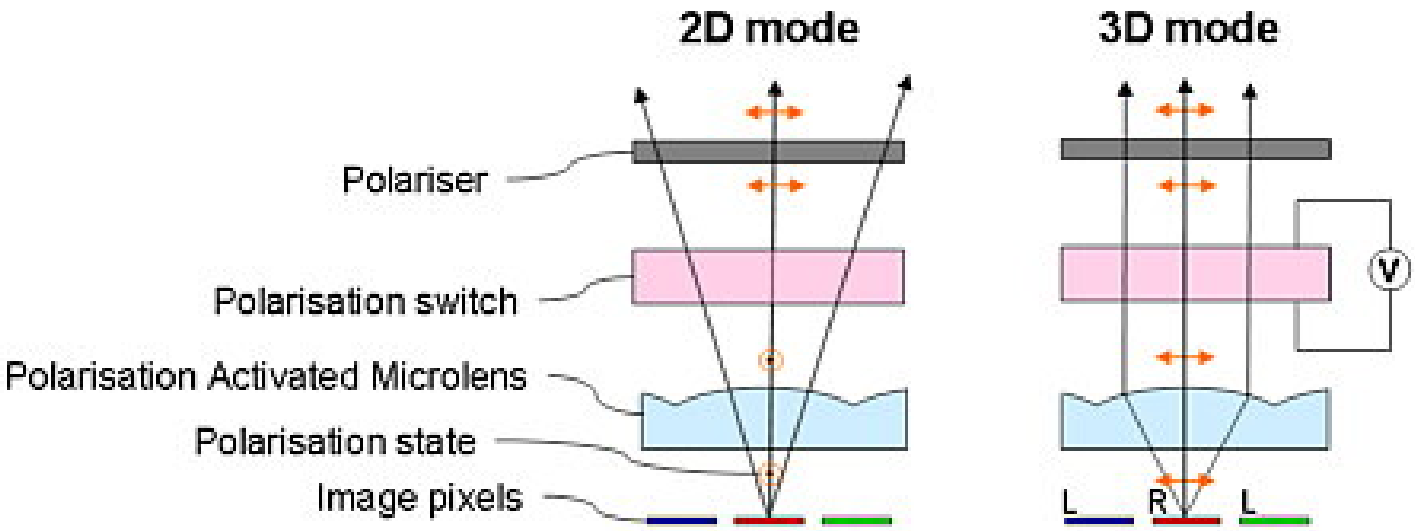
- Pixel & lenticular lens layout



S. T. deZwart, W. L. IJzerman, T. Dekker, and W. A. M. Wolter, "A 20-in. switchable auto-stereoscopic 2D/3D display," Proc. IDW '04, pp. 1459-1460, Niigata, Japan, Dec. 8-10, 2004.

Solid phase LC lens - Ocuity

- Operation principle



J. Harrold, D. J. Wilkes, and G. J. Woodgate, "Switchable 2D/3D display - solid phase liquid crystal microlens array," Proc. IDW '04, pp. 1495-1496, Niigata, Japan, Dec. 8-10, 2004.

2D / 3D 변환 PDA: Ocuity

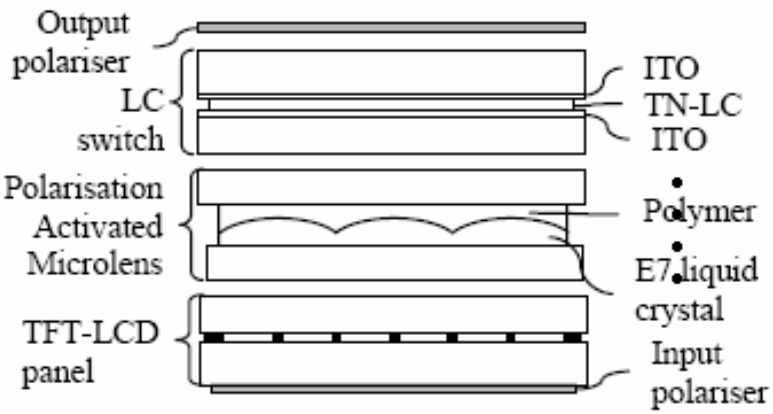


Fig.1 4-substrate Polarisation Activated Microlens reconfigurable 2D/3D display

Switchable 2D/3D PDA

PDA base platform

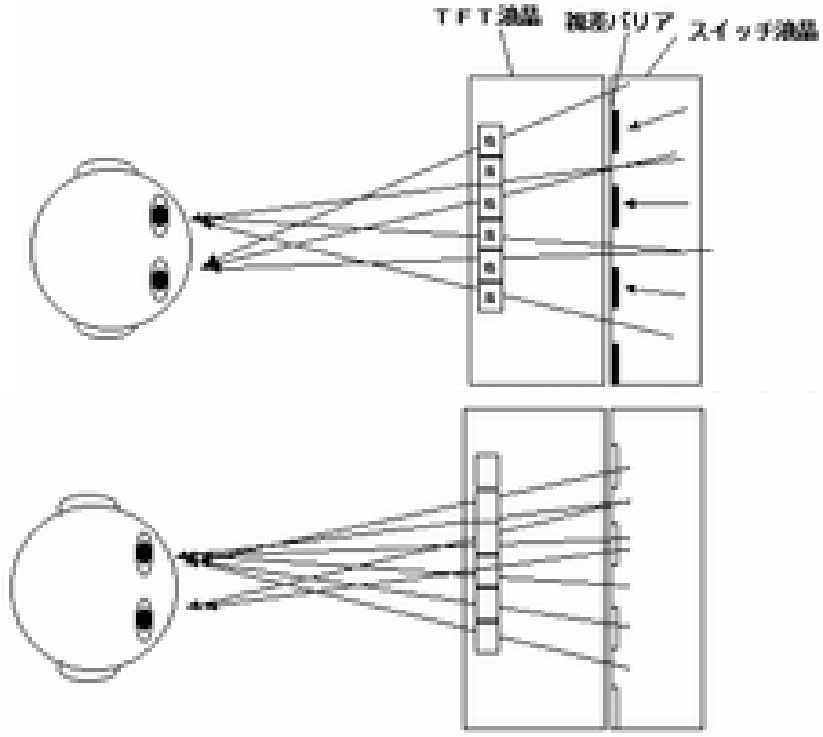
3.8” Transmissive TFT-LCD

320xRGBx240 pixel display

Full brightness in 2D and 3D

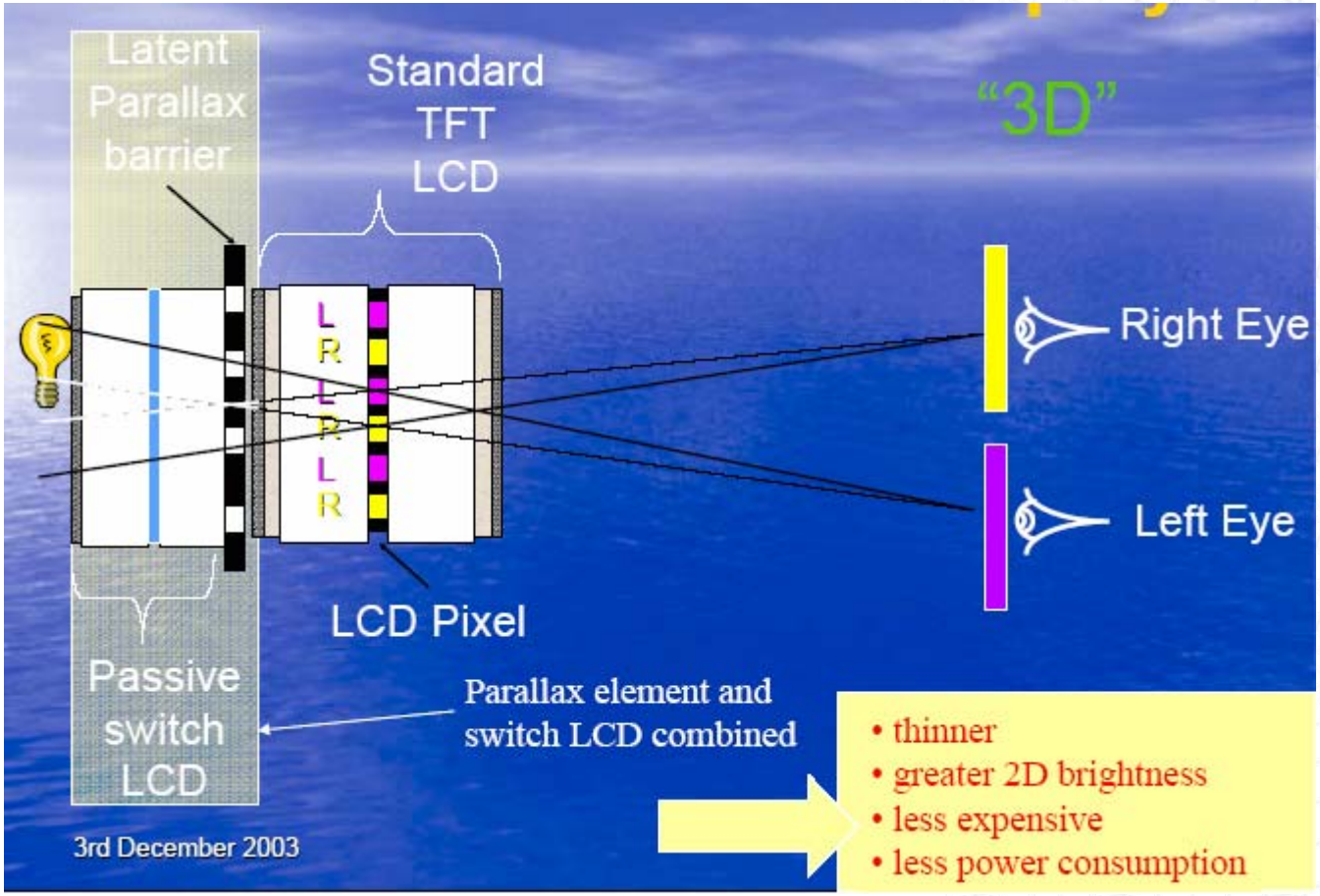
SH251iS (2002년 11월 출시: 샤프 / NTT도코모)

カメラ付携帯電話「ムーバ SH251iS」
(S:スカイシルバー、W:ジュエルホワイト、K:エレガントブラック)
※写真はスカイシルバー



패럴랙스 배리어 방식으로,
액정 배리어를 전기적으로 제어해 3D/2D 변환

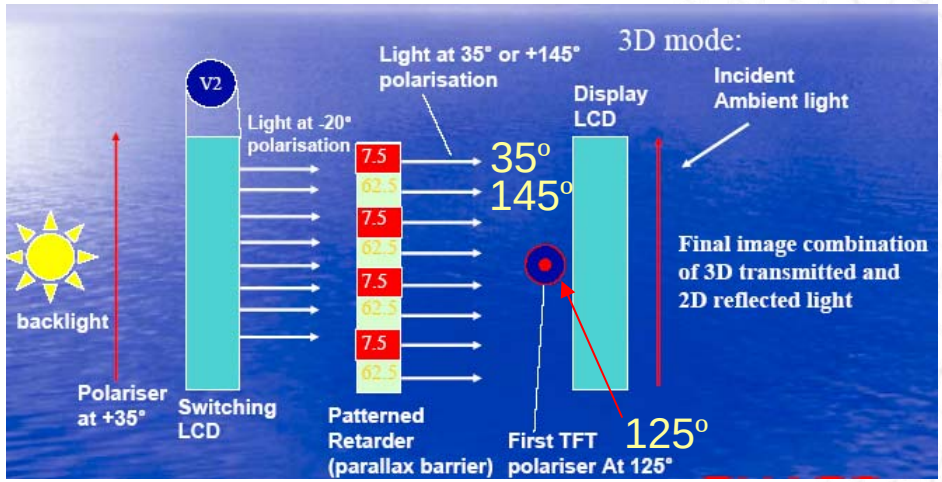
Switchable Parallax Barrier -Sharp



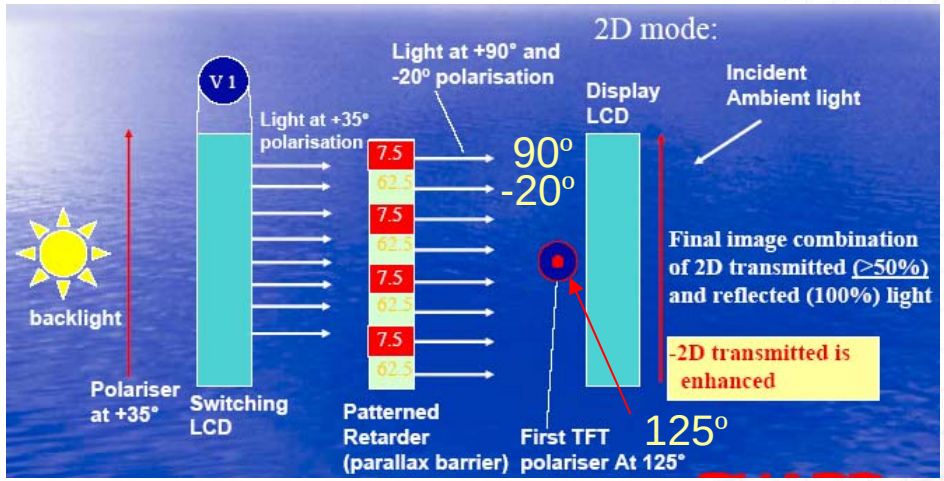
Sharp, IDW 2003

Continued - Sharp

- 3D



- 2D



3D 휴대폰: SAMSUNG SDI

3D 휴대폰 - KIST

3D Moving Image Display with a Cellular Phone

Data Transfer Rate : A Pair of Stereo Images / 3 Seconds
Limitation : Network Channel Capacity

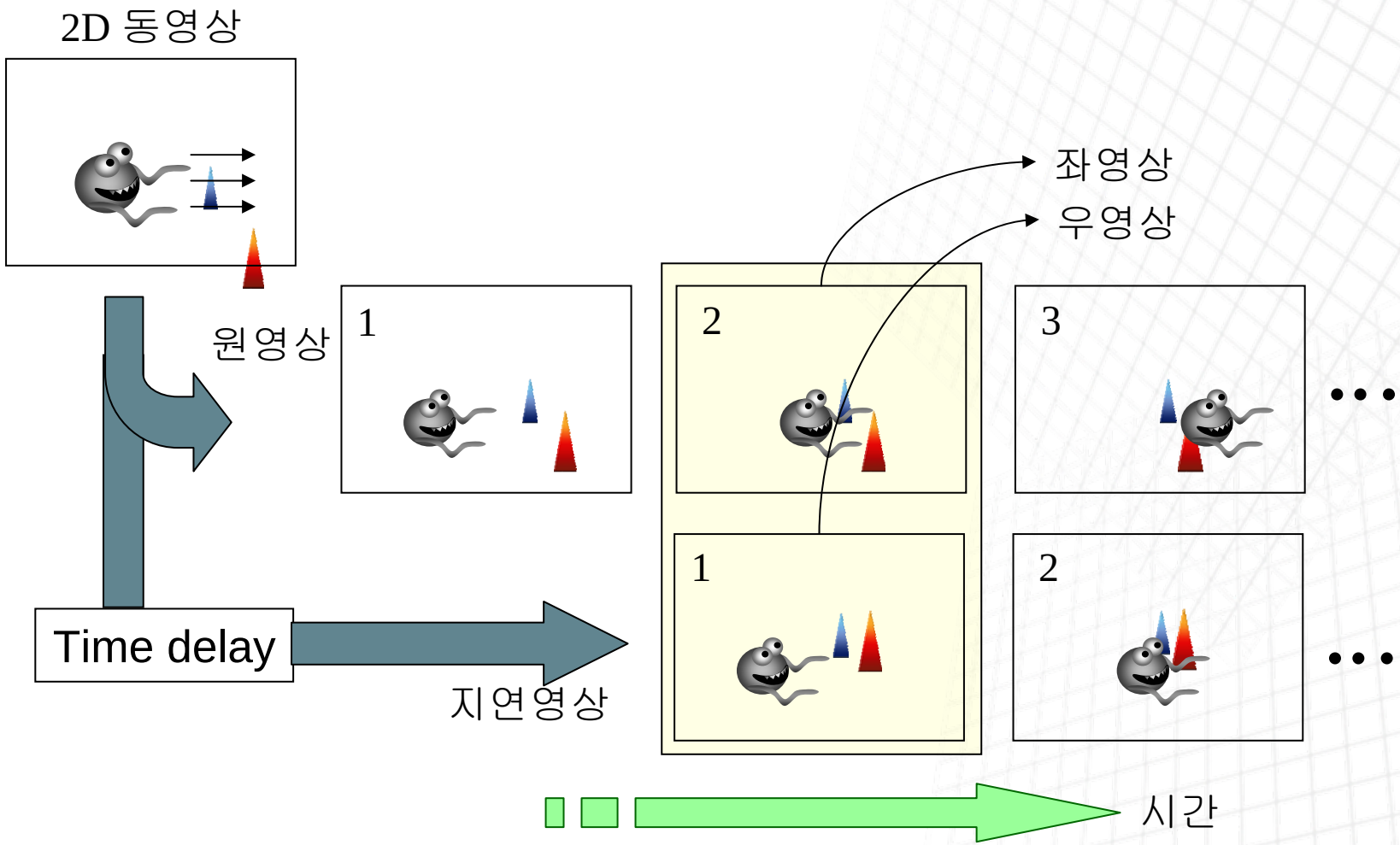
A Parallax Barrier Film is layered on a Cellular Phone Screen

3D 휴대폰: NEC

2차원과 3차원이 동시에 부분적으로 디스플레이 가능
2.5인치 640×480의 해상도

HDDP(Horiaontally Double-Density Pixel)

2D movie 의 3D 전환 (I)



2D movie 의 3D 전환 (II)

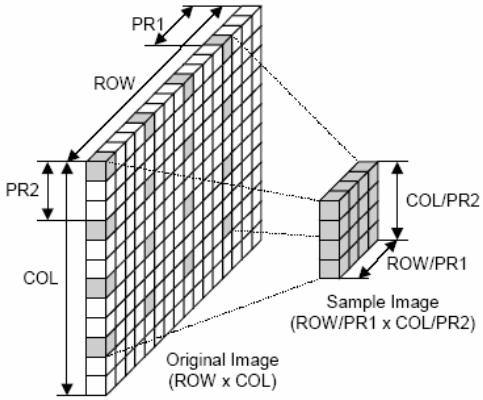
Image Sampling

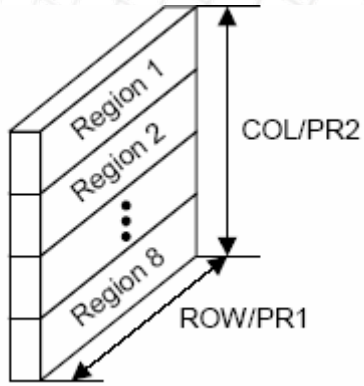
Motion Detection and Region Segmentation

Depth Map Generation

Mask Filtering

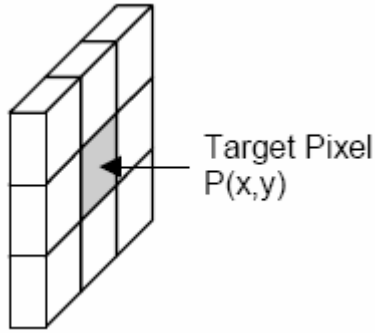
Parallax Processing





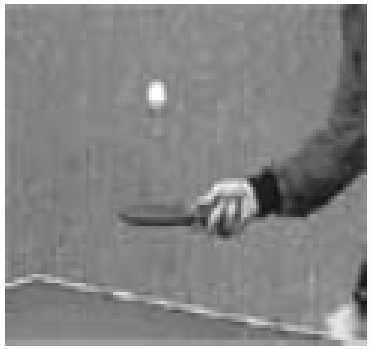
$$D_{Pixel} = \left| P_{(N)th} - P_{(N-1)th} \right|$$

$$P_{(N)th} = \begin{cases} Moving\ Pixel & \text{if } (D_{pixel} > D_{th}) \\ Static\ Pixel & \text{otherwise} \end{cases}$$

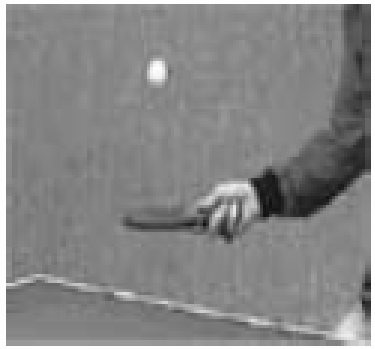


C.-H. Choi *et al*. "A Real-Time Field-Sequential Stereoscopic Image Converter," IEEE Transactions on Consumer Electronics, Volume: 50 , Issue: 3 , Aug. 2004
Pages:903 - 910.

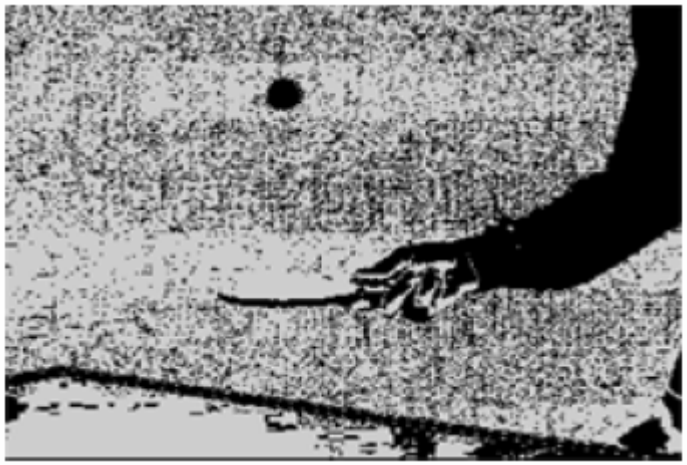
Continued…

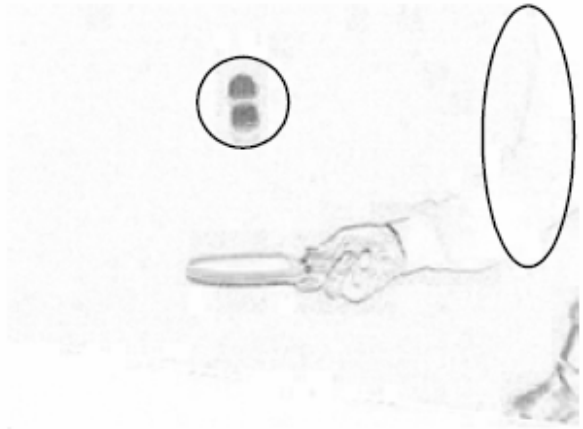


(a) the (N-1)th frame

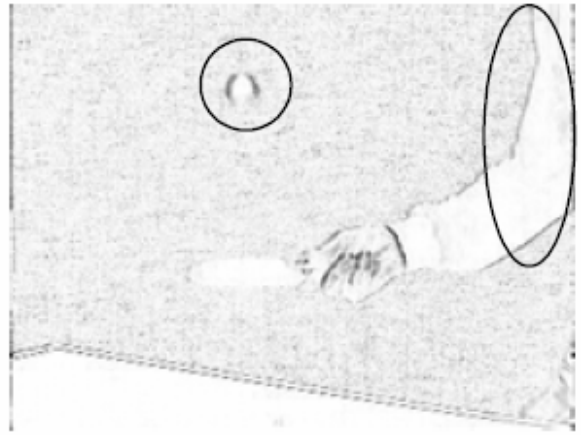


(b) the (N)th frame



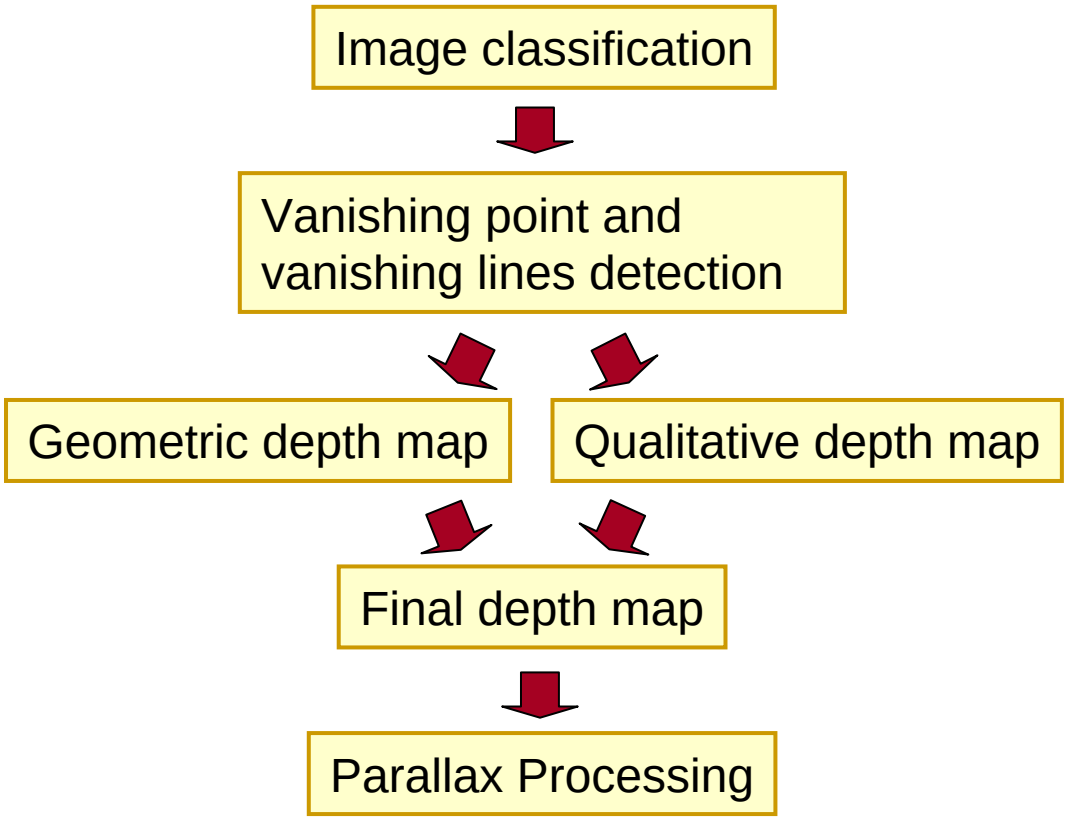


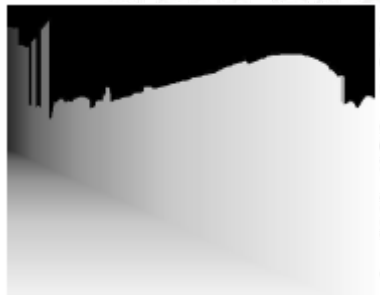
(a) MTD



(b) the proposed method

2D movie 의 3D 전환 (III)





S. Battiato et al. “3D Stereoscopic Image Pairs by Depth-Map Generation,” Proc. The 2nd International Symposium on 3D data processing, visualization, and transmission (3DPVT’04), 124-131, Sep. 2004.

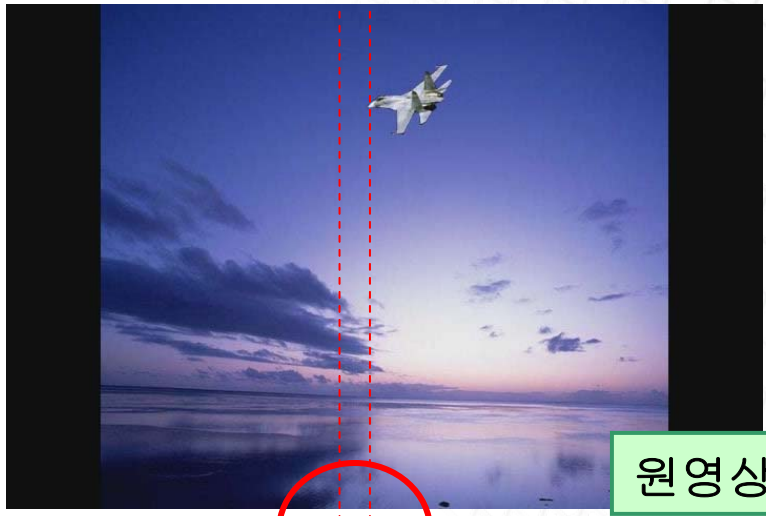
MPEG 2D movie 의 3D 전환

Motion vector extraction

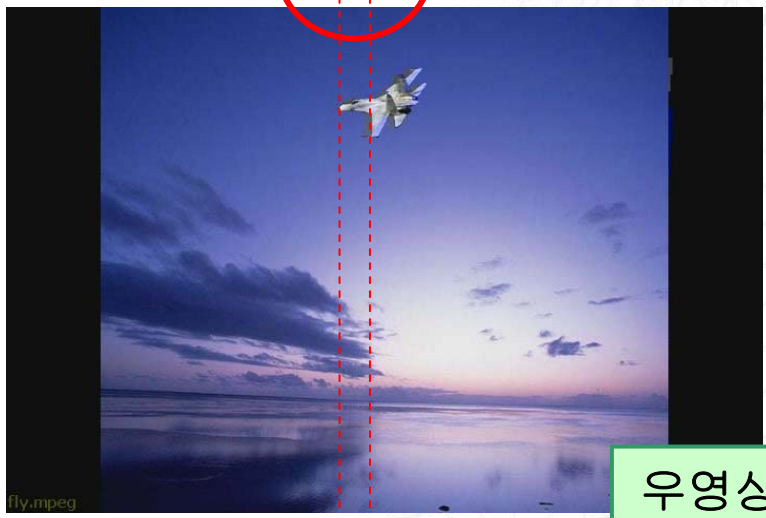
Depth map generation

Right movie generation

표현하고 싶은 깊이만큼 수평 이동 하여 우영상 제작

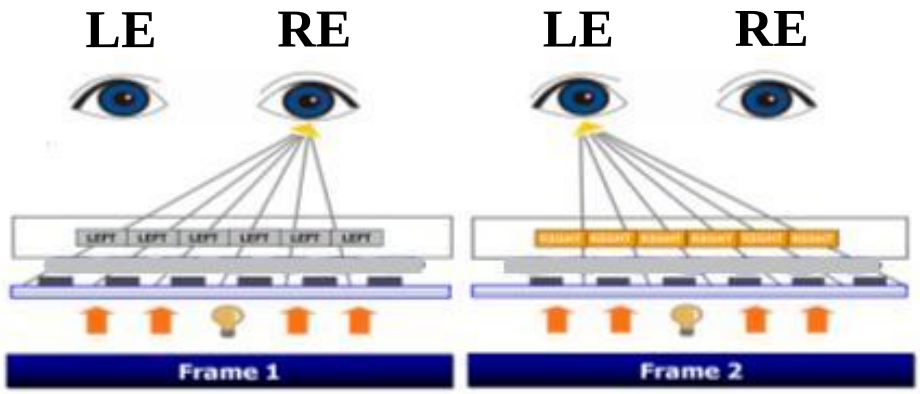


원영상



우영상

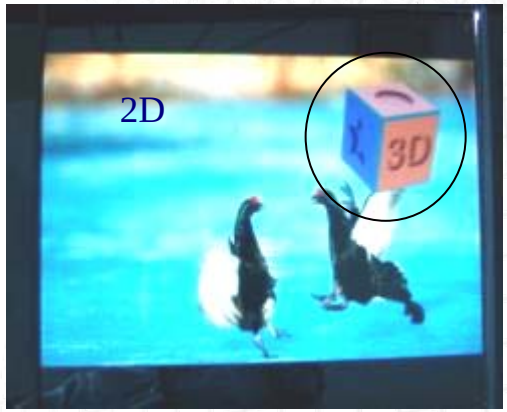
Field sequential – Samsung



- **Frame 1 (60Hz) : All light rays → Right Eye**
- **Frame 2 (60Hz) : All light rays → Left Eye**

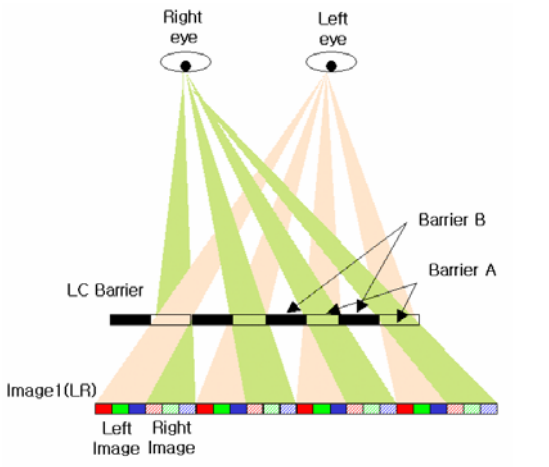
[한국정보디스플레이학회 2006 3D Workshop (서울대)]

(a) Local 2D mode

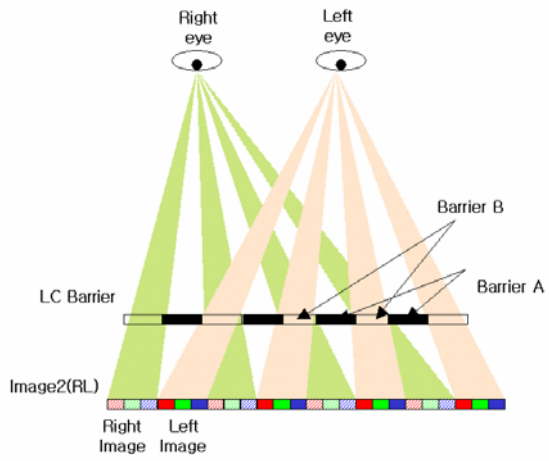


(b) Local 3D mode

Field sequential - Samsung SDI

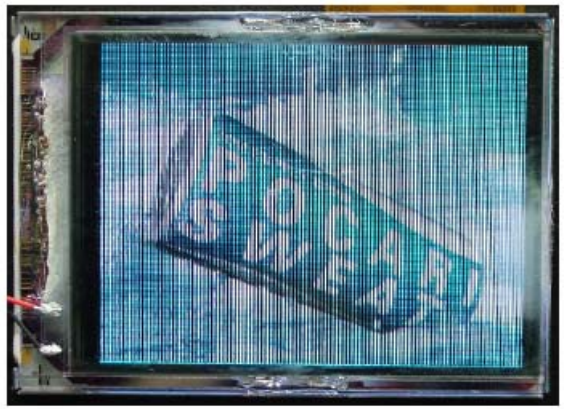


a) First period



b) Second period

(a) TD Parallax Barrier



(b) Conventional Parallax Barrier

[한국정보디스플레이학회 **2006 3D Workshop** (서울대)]

Field sequential - Samsung SDI

- **Time multiplexing**
  - Doubled 3D resolution
  - Moire pattern decreased.
- **High speed switching**
  - OCB* mode LC barrier
  - AMOLED display panel

* Optically Compensated Birefringence

Field sequential

- Advantages
  - Enhanced 3D resolution
  - 3D/2D convertible (local 3D)
  - Easy to fabricate
- Disadvantages
  - High speed switching (>120Hz)
  - Low 3D luminance

3차원 디스플레이의 최근 기술

Autostereoscopic 방식
Holography
집적 영상 방식
Volumetric 방식과 그 외

Holography

- Dennis Gabor (1948, 1949, 1951) ••• Nobel Prize in Physics (1971)

  holography

  “whole recording”

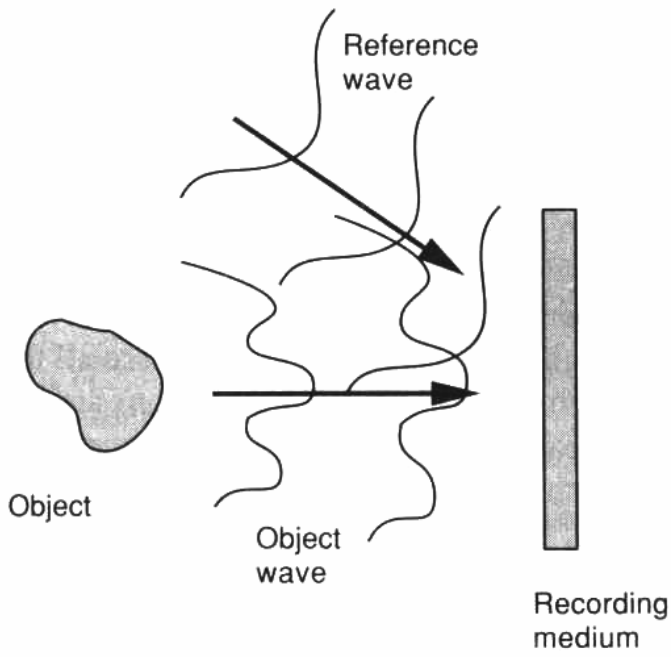
  - On-axis hologram

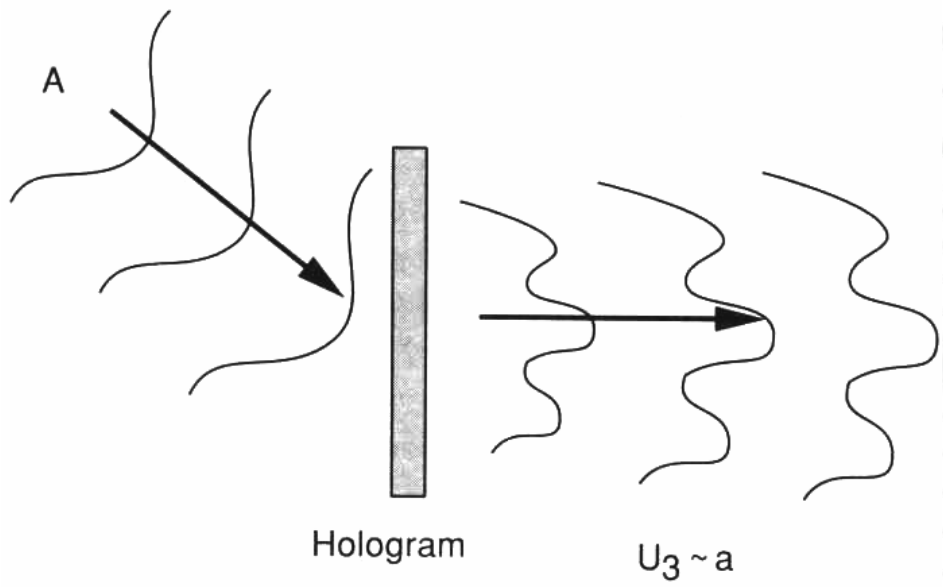
- E. N. Leith and J. Upatnieks (1962, 1963)

  - Off-axis hologram

- Y. N. Denisyuk (1962, 1963, 1965)

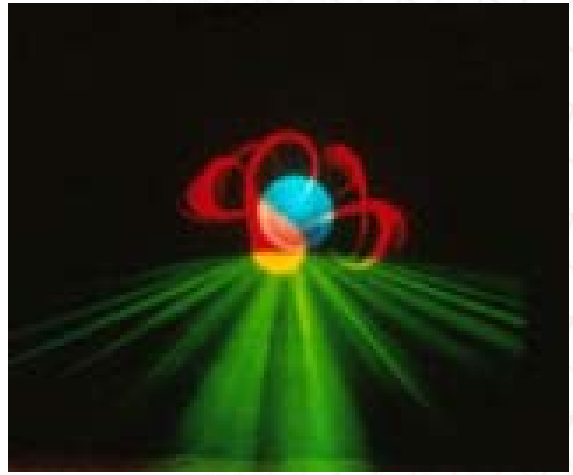
Hologram Recording and Retrieval

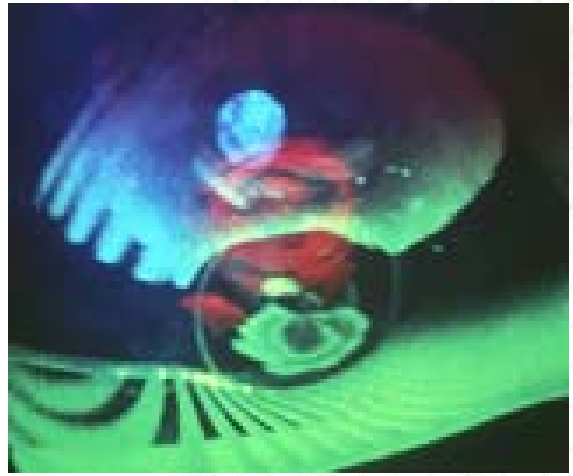




Early holograms

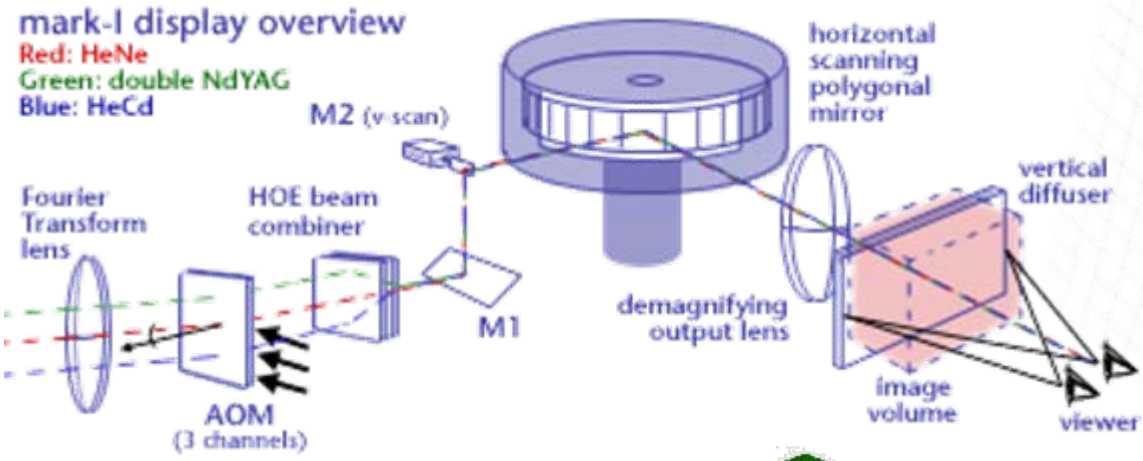
Bird and Train, by Emmett N. Leith and Juris Upatnieks, 1960, one of the earliest laser transmission images.



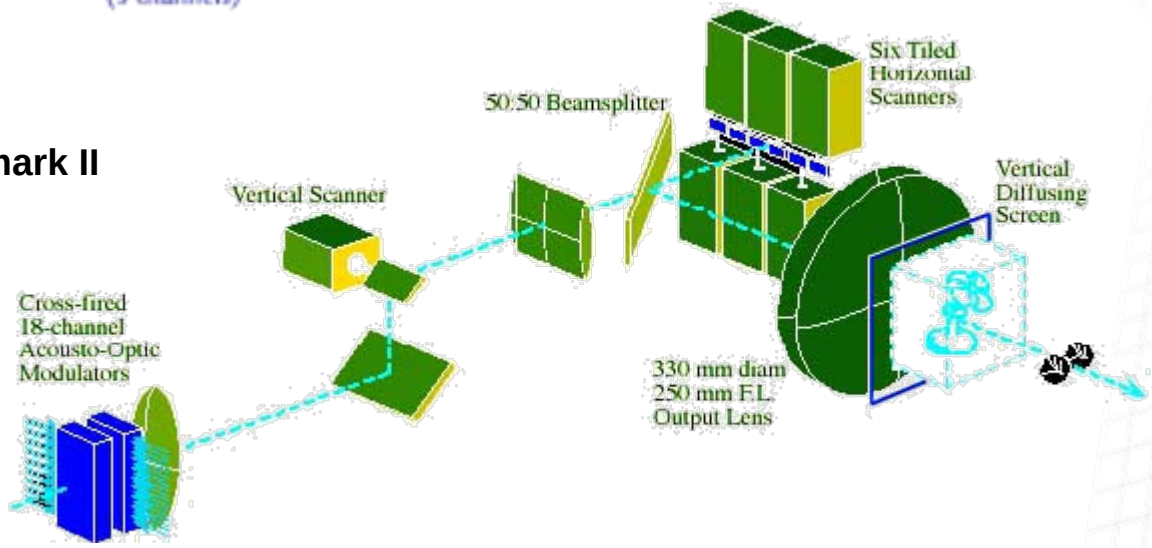


The Seed, an abstract white light transmission hologram by Dan Schweitzer, 1980.

Electro-holography

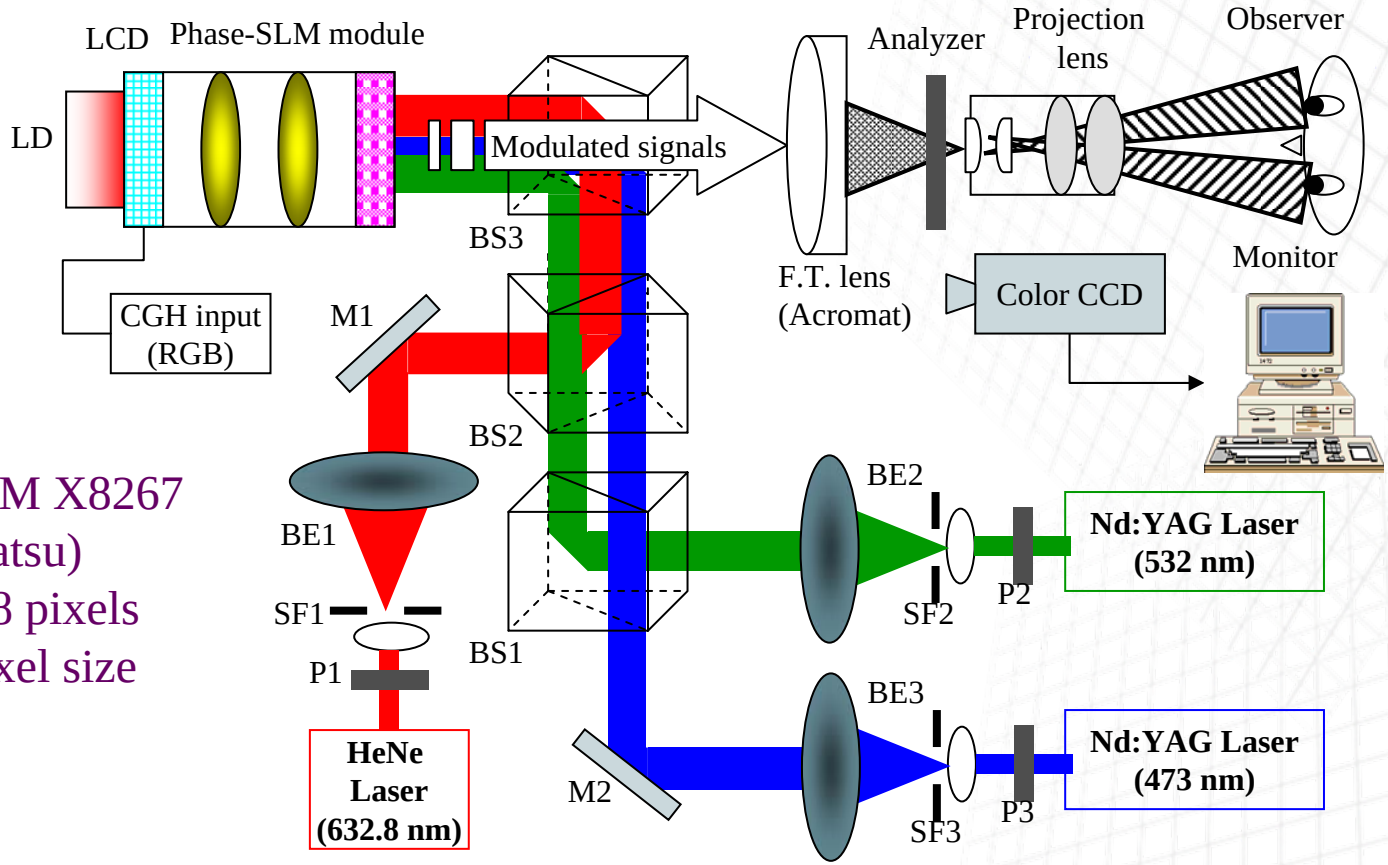


mark II



[MIT]

Electro-holography: Spatial Light Modulator



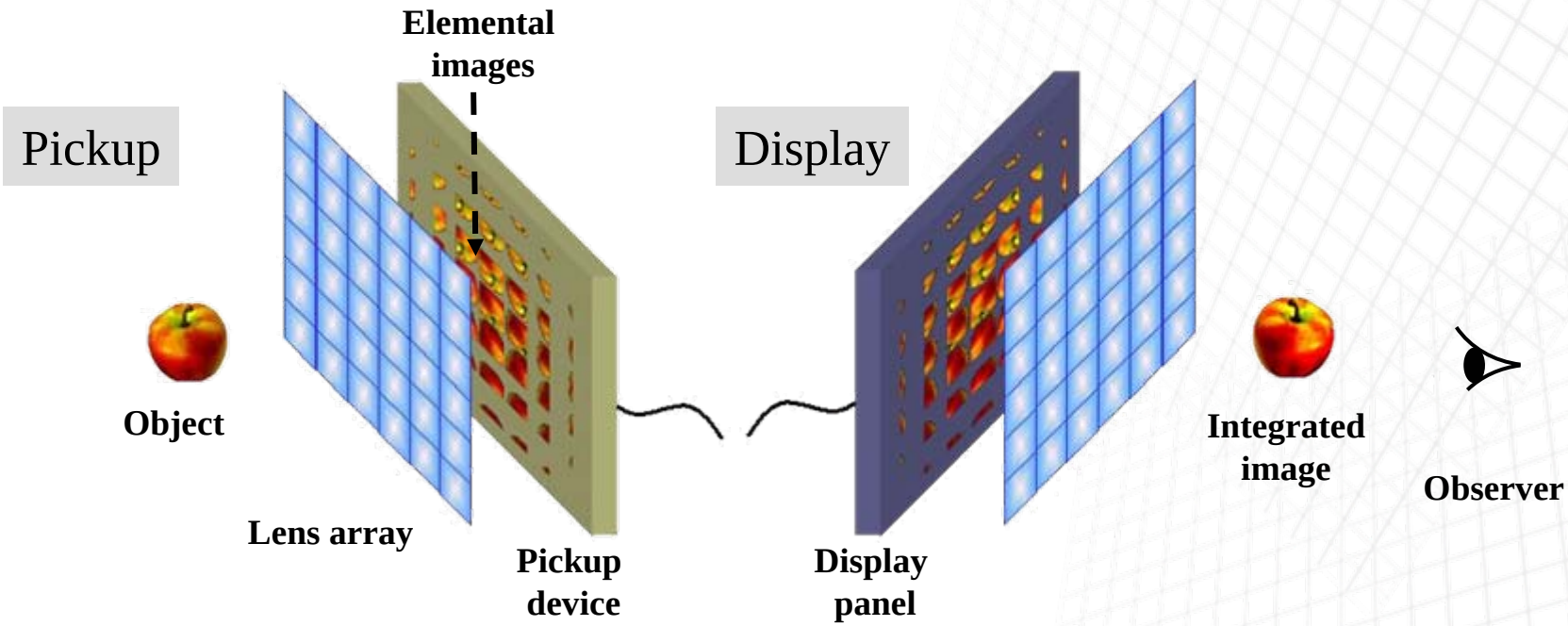
SLM: PPM X8267
(Hamamatsu)
1024x768 pixels
25 um pixel size

K. Choi, H. Kim, and B. Lee, *Optics Express*, vol. 12, no. 11, p. 2454, 2004.
K. Choi, H. Kim, and B. Lee, *Optics Express*, vol. 12, no. 21, p. 5229, 2004.

3차원 디스플레이의 최근 기술

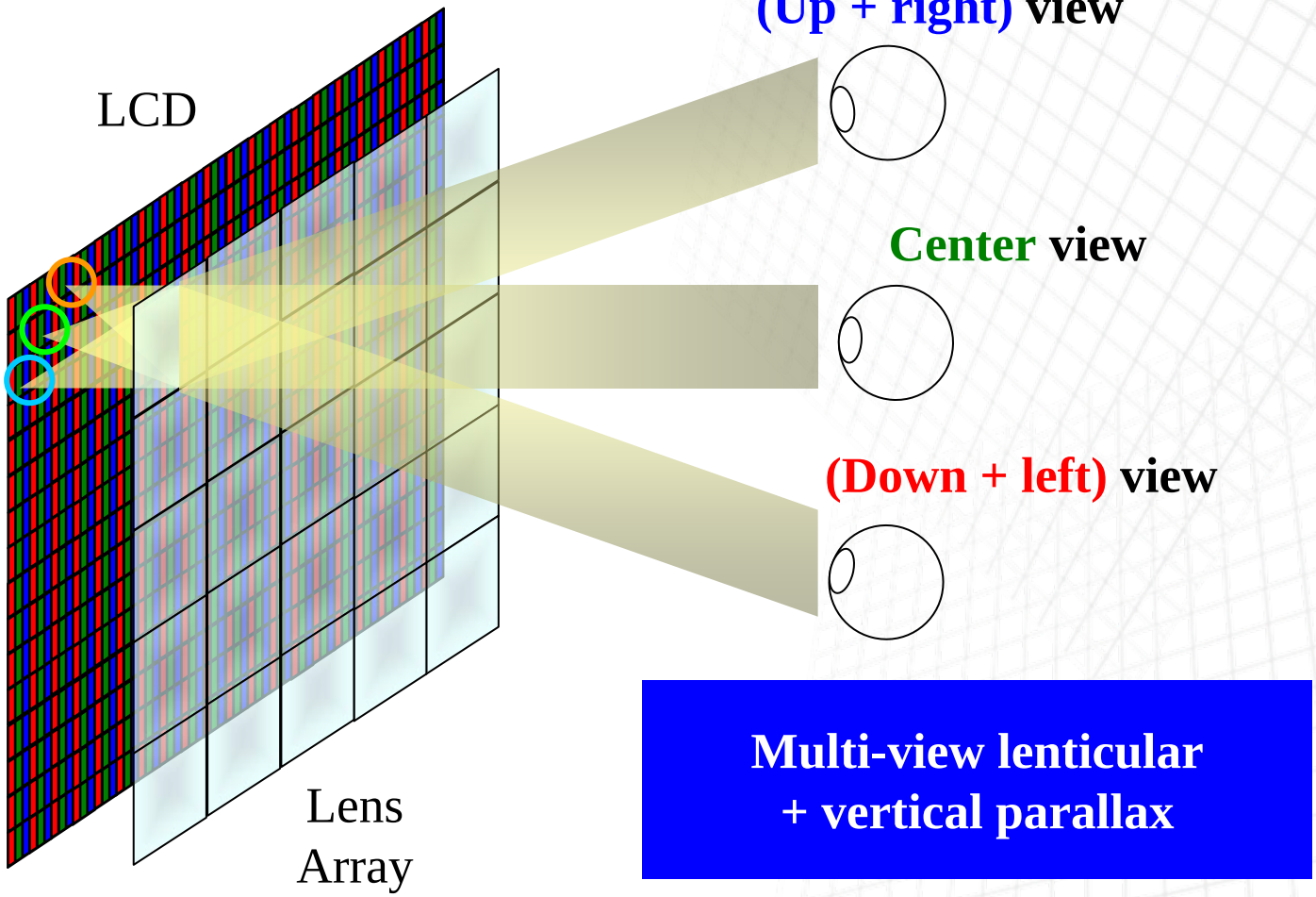
Autostereoscopic 방식
Holography
집적 영상 방식
Volumetric 방식과 그 외

Integral Imaging (Integral Photography)



- Pickup : Obtaining elemental images
- Display : Retracing the original routes and forming a 3D image

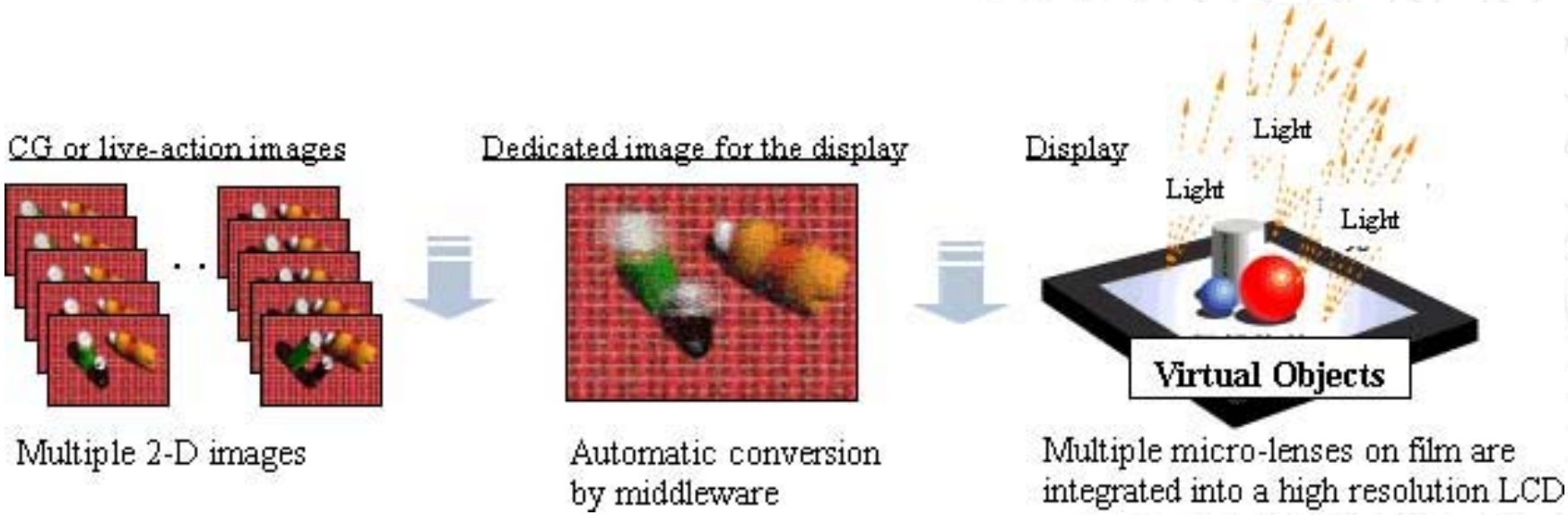
Integral imaging



Integral imaging

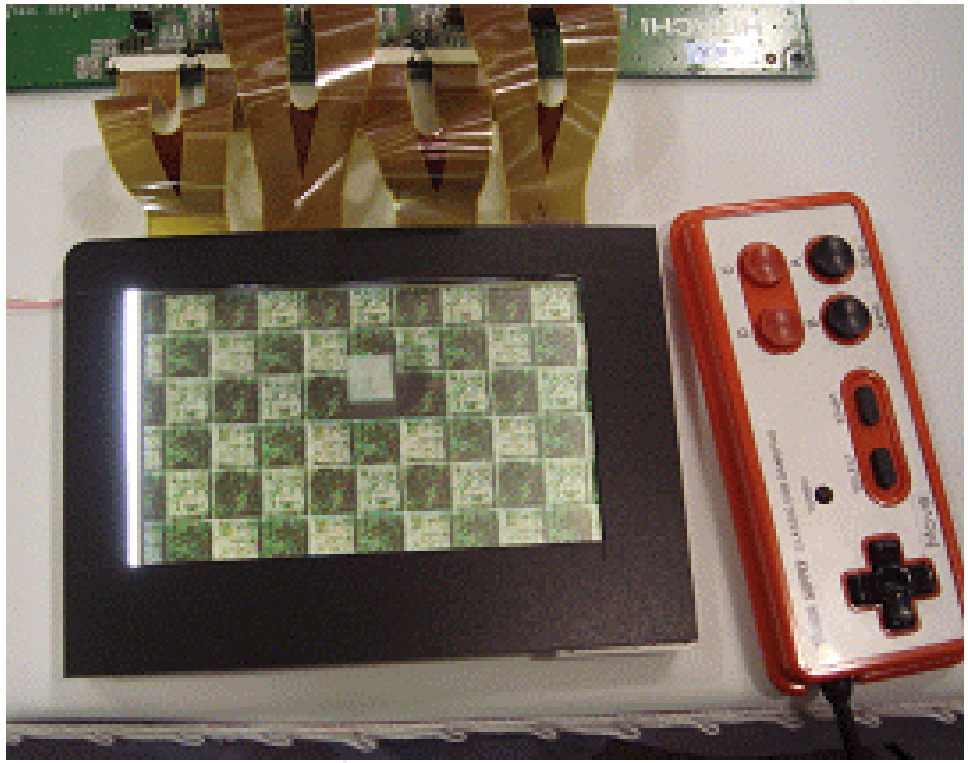
- Advantages
  - High 3D luminance
  - Full parallax
  - Quasi-continuous viewpoints (viewing angle)
- Disadvantages
  - Low 3D resolution
  - Moire pattern
  - Color dispersion
- **Issues**
  - Limitation in image depth
  - Limitation in resolution
  - Limitation in viewing angle
  - 2D/3D convertibility

Integral imaging - Toshiba



- Viewing angle: 20 degrees
- 32 views for natural continuous view
- 20.8 inch size

Integral imaging – Hitachi/동경대

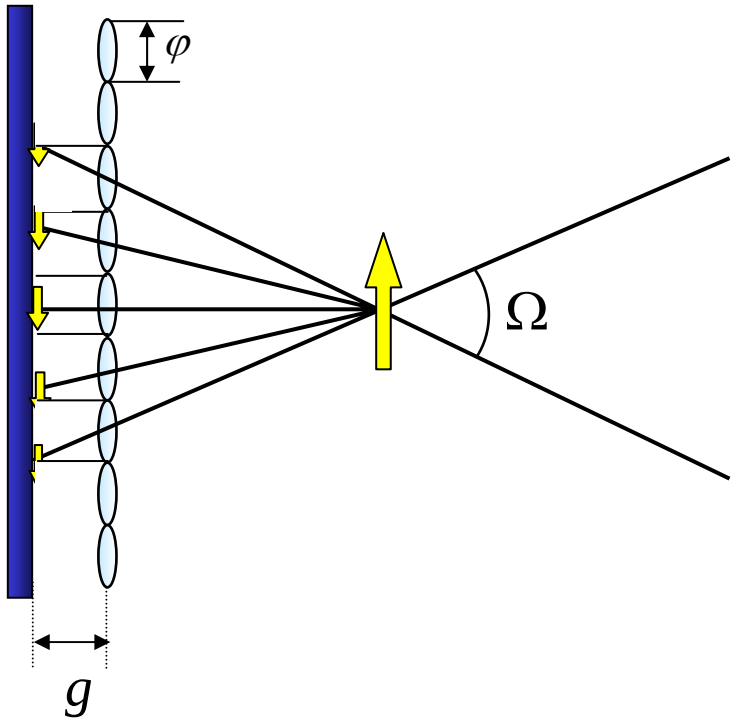


5인치 모바일
Color filter를 최적화
900dpi의 LCD와 마이크로 렌즈 어레이를 이용

Example of 20-inch Demonstration System

40-inch Projection-type Integral Imaging System

Limitation of viewing angle

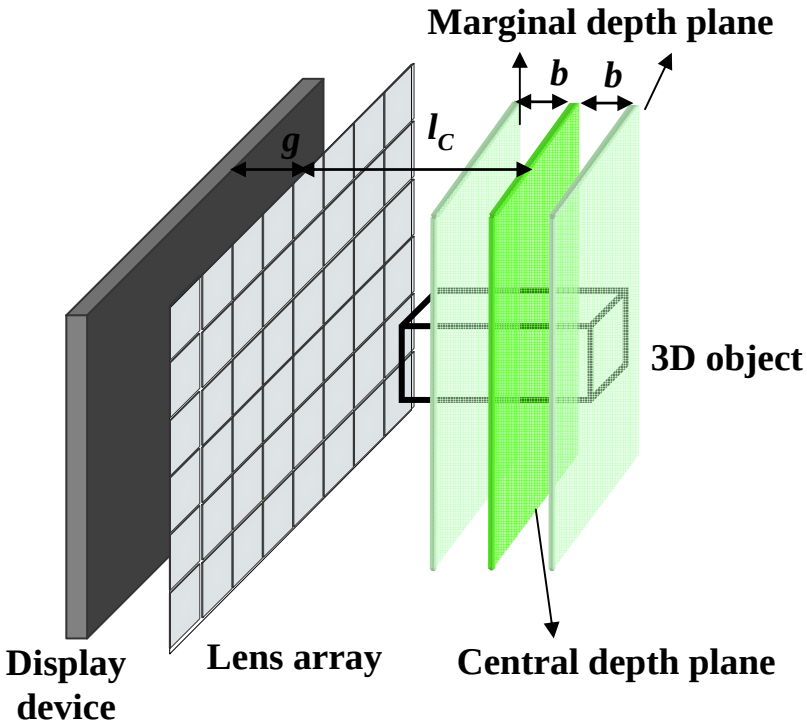


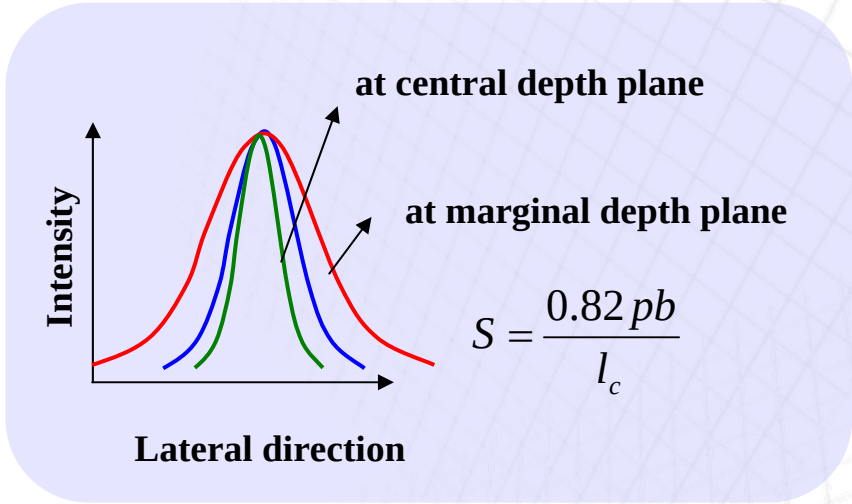
- 각 **elemental image**는 그에 해당하는 **elemental image** 영역 내에서만 표시된다.

- **Viewing angle**

$$\Omega = 2\arctan(\varphi / 2g)$$

Limitation of depth





- The gap, g, and the focal length of lens array, f, determine the location of central depth plane, l_c, by lens law.

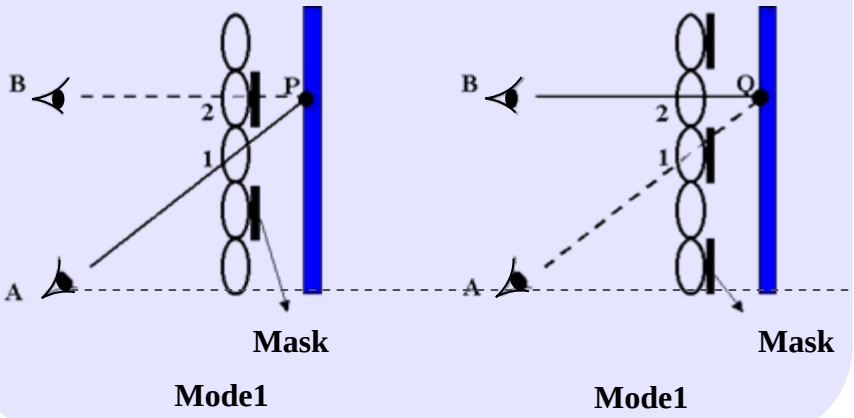
$$\frac{1}{g}+\frac{1}{l_c}=\frac{1}{f}$$

- The quality of 3D image is degraded as the image gets farther from central depth plane.

Expressible depth is limited.

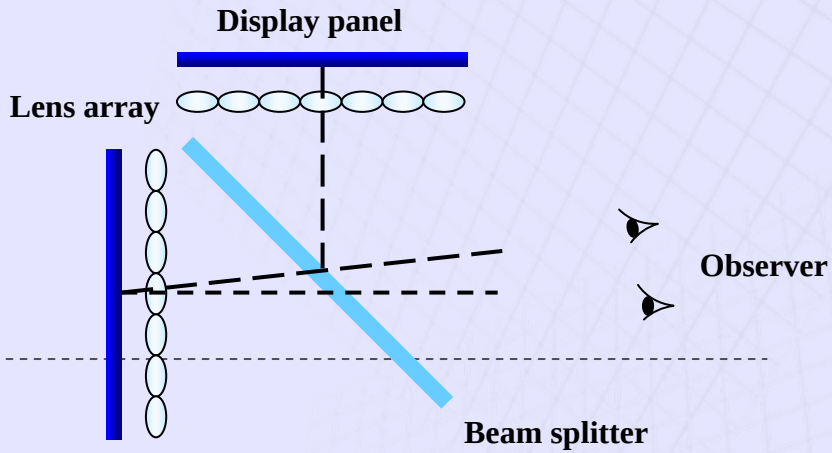
Viewing angle enhancements

Lens switching



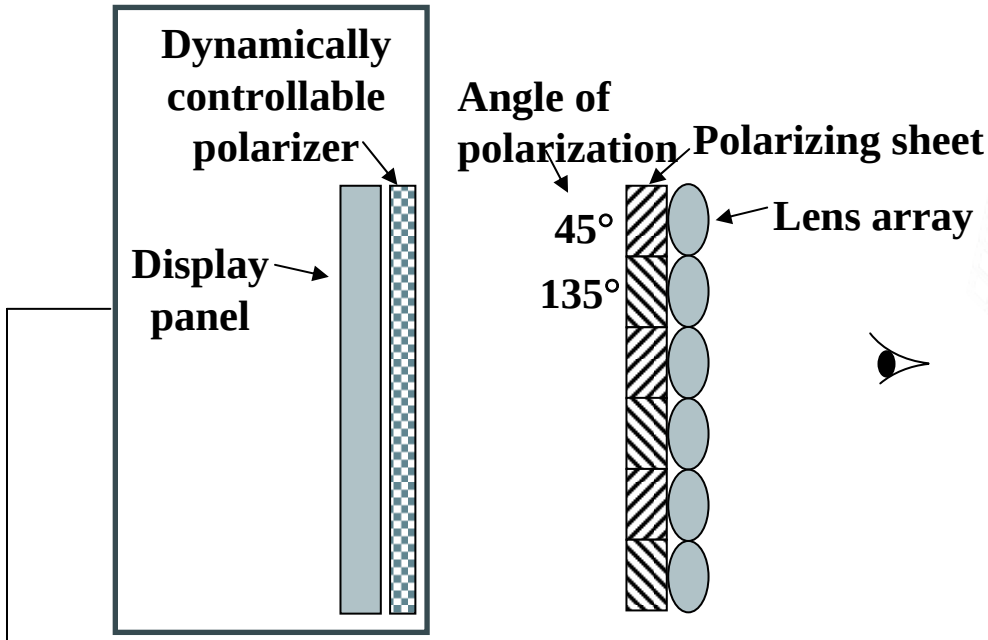
B. Lee, S. Jung, and J.-H. Park, *Optics Letters*, vol. 27, no. 10, pp. 818-820, 2002.

Double device



S.-W. Min, B. Javidi, and B. Lee, *Applied Optics*, vol. 42, no. 20, pp. 4186-4195, 2003.

Viewing angle enhancement: Polarization-Multiplexing Method



45 ° polarized

135 ° polarized

This part can be replaced with a polarizing shutter screen which is commercially available in the stereoscopy display.

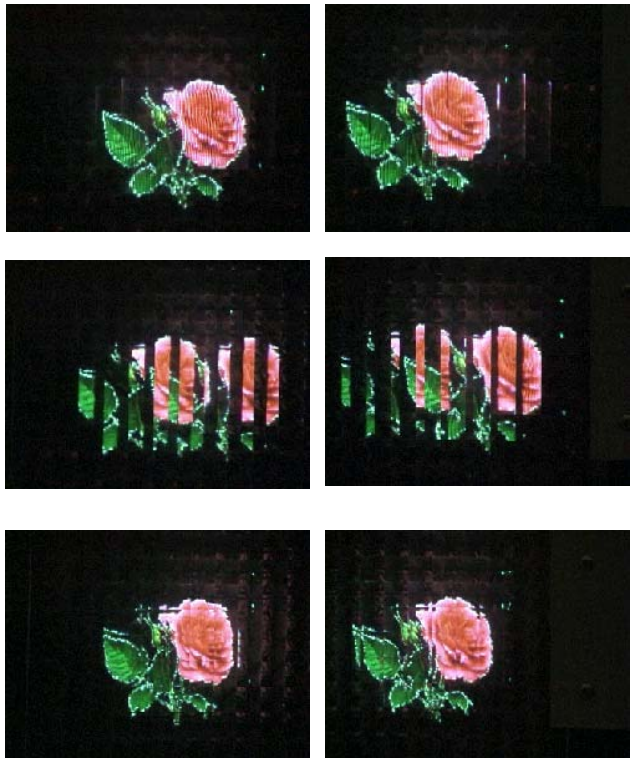
S. Jung, J.-H. Park, H. Choi, and B. Lee, "Wide-viewing integral three-dimensional imaging by use of orthogonal polarization switching," *Applied Optics*, vol. 42, no. 14, pp. 2513-2520, 2003.

B. Lee, S. Jung, and J.-H. Park, "Viewing-angle-enhanced integral imaging using lens switching," *Optics Letters*, vol. 27, no. 10, pp. 818-820, 2002.

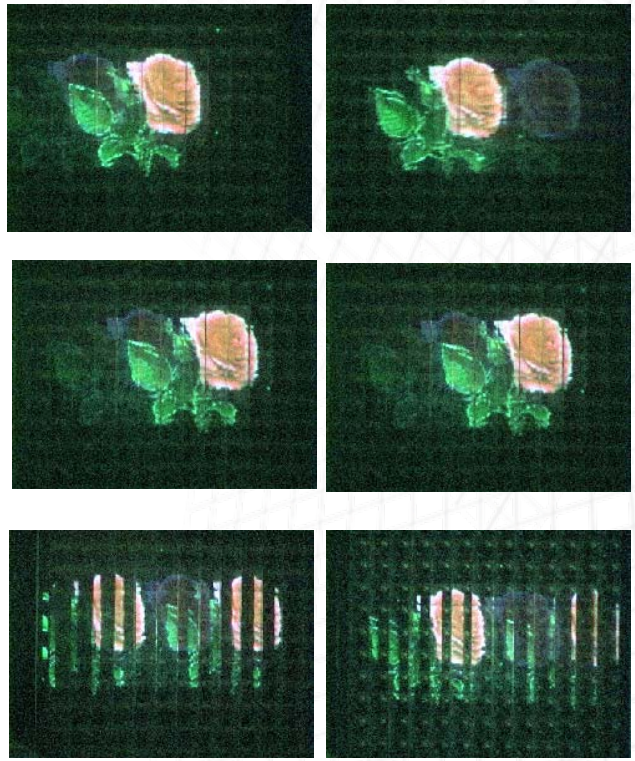
Comparison of Viewing Angle

from left 6°	from right 6°
from left 11°	from right 11°
from left 17°	from right 17°

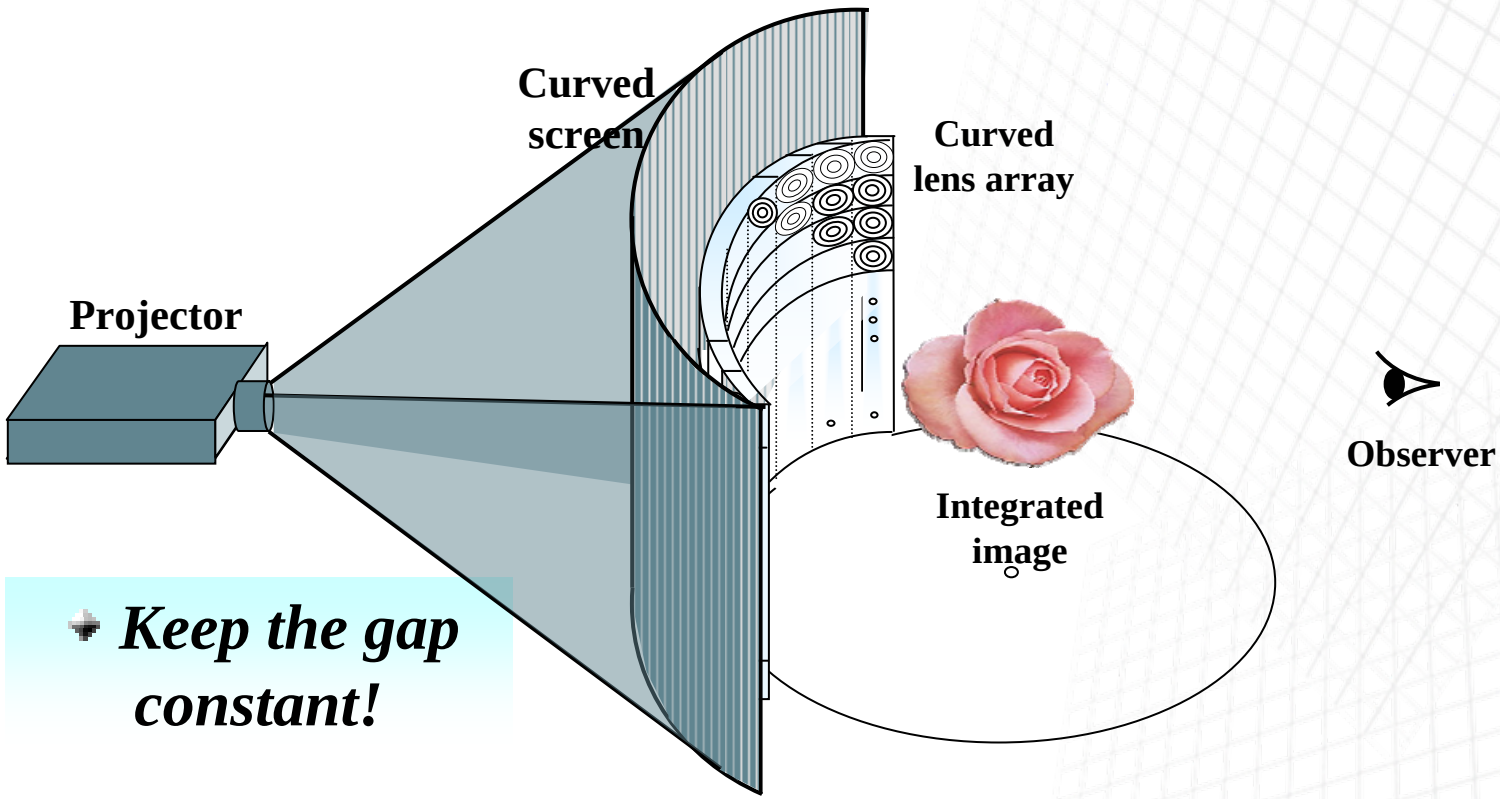
- Conventional



- Proposed



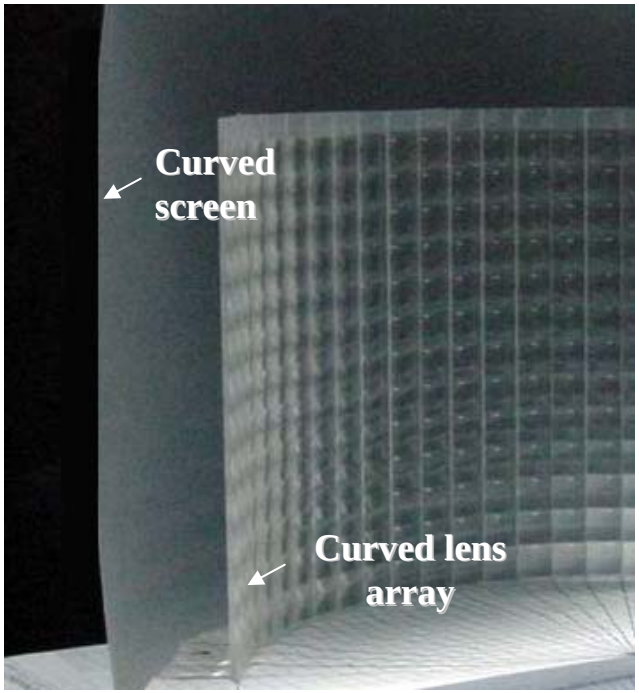
Curved Screen & Curved Lens Array



Y. Kim, J.-H. Park, S.-W. Min, S. Jung, H. Choi, and B. Lee, "Wide-viewing-angle integral three-dimensional imaging system by curving a screen and a lens array," *Applied Optics*, vol. 44, no. 4, pp. 546-552, 2005.

Y. Kim, J.-H. Park, H. Choi, S. Jung, S.-W, Min, and B. Lee, "Viewing-angle-enhanced integral imaging system using a curved lens array," *Optics Express*, vol. 12, no. 3, pp. 421-429, 2004.

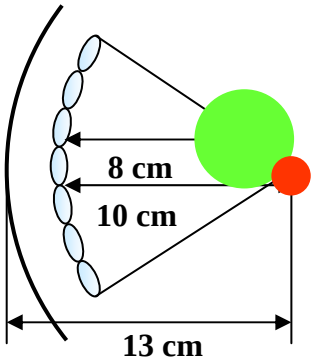
Experimental Setup

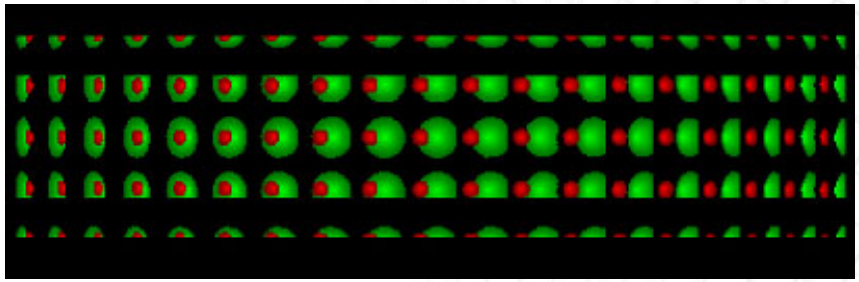


• Experimental setup without barriers

Setup	Specification	Characteristics
Lens array	Focal length	22 mm
	Number of elemental lenses	19(H) × 13(V)
	Pitch of an elemental lens	10 mm
	Radius of curvature	100 mm
Barriers	Rectangular plate	26 mm(H) × 140mm(V)
Screen	Thickness	0.6 mm (transmission type)
	Radius of curvature	130 mm
Elemental image	Pixel pitch	0.480mm(H) × 0.465mm(V)
Projector	Epson EMP-7700	

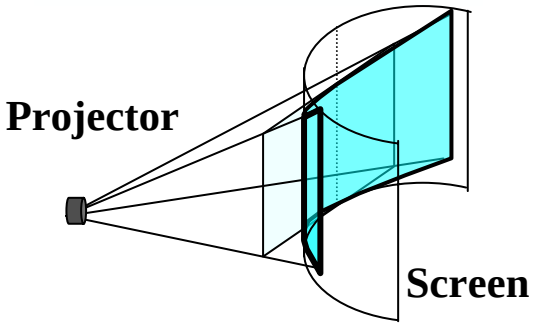
Elemental image region

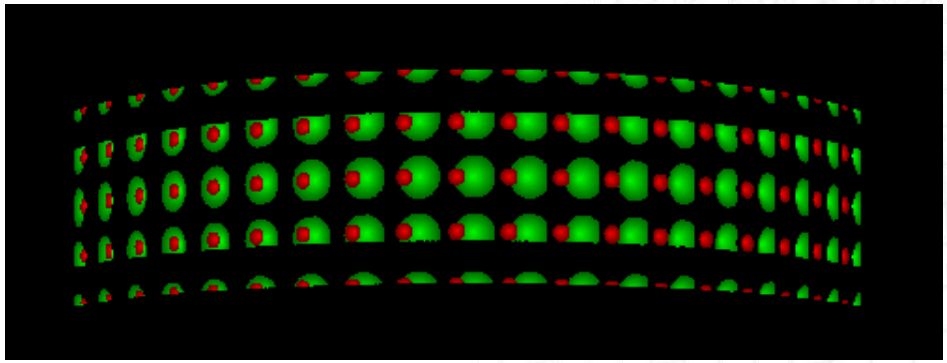




• Elemental image in ideal case

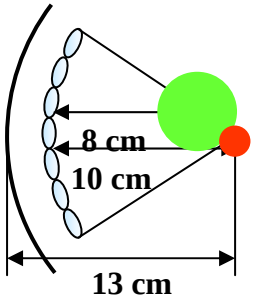
• Correction of the distortion



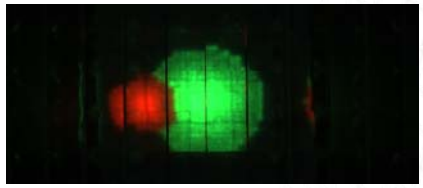


• Corrected elemental image

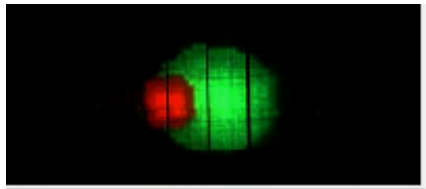
Experimental Result



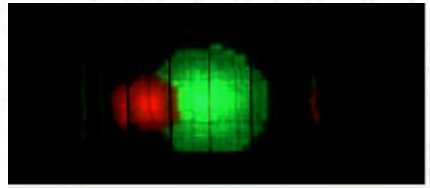
Center



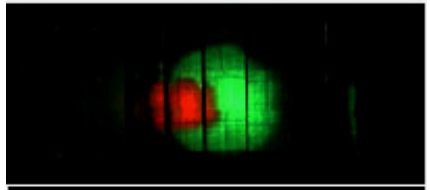
Left10°



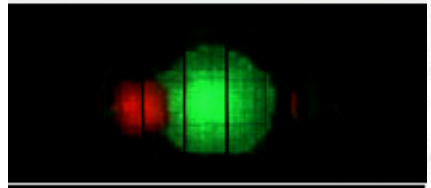
Right10°



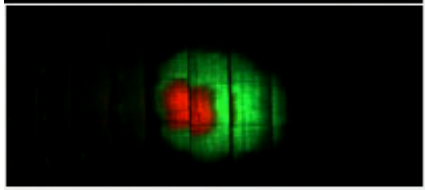
Left20°



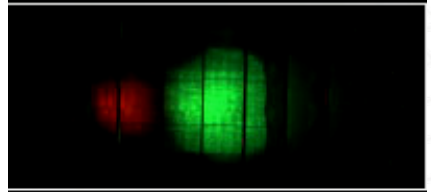
Right20°



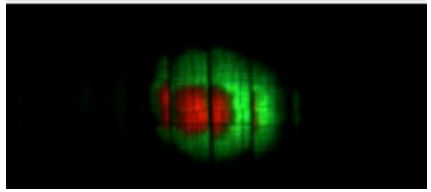
Left29°



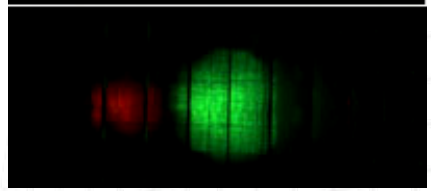
Right29°



Left33°

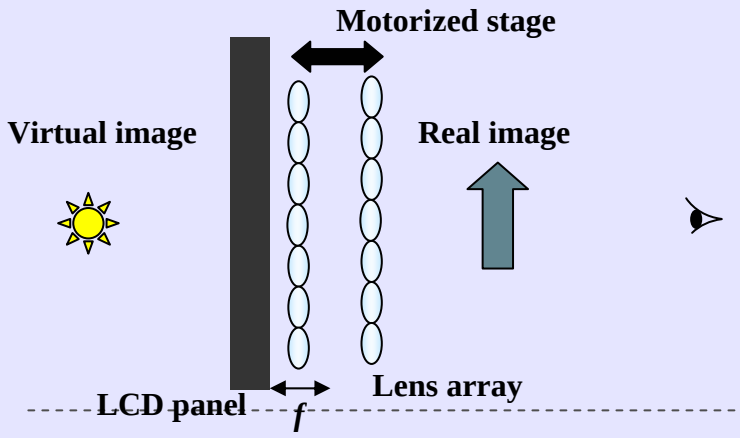


Right33°



Depth enhancements

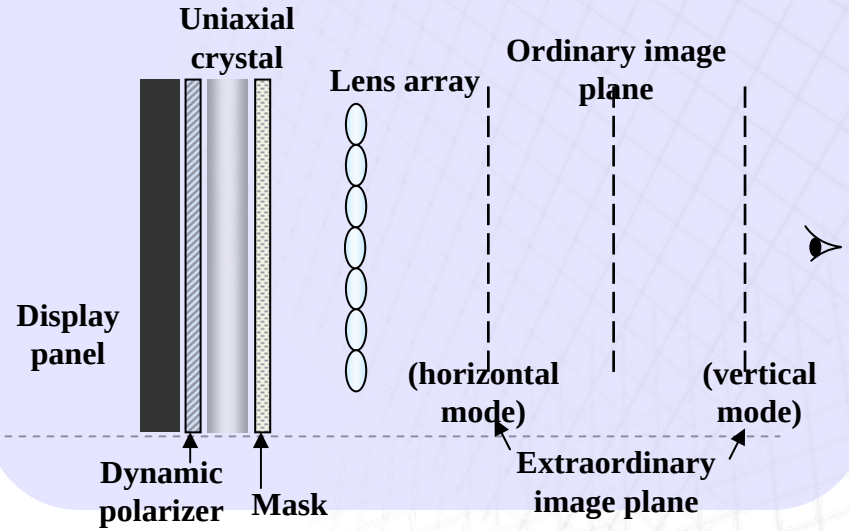
Moving lens



$$\frac{1}{g}+\frac{1}{l_c}=\frac{1}{f}$$

B. Lee, S. Jung, S.-W. Min, and J.-H. Park, *Opt. Lett.*, vol. 26, no. 19, pp. 1481-1482, 2001.

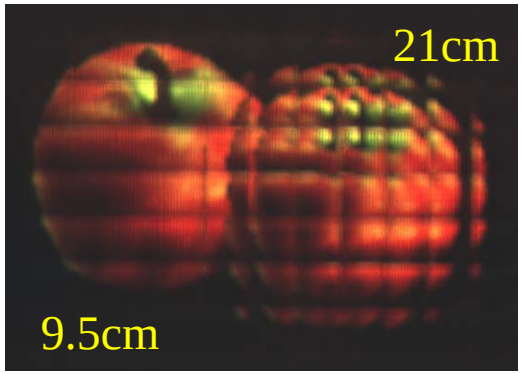
Uniaxial crystal



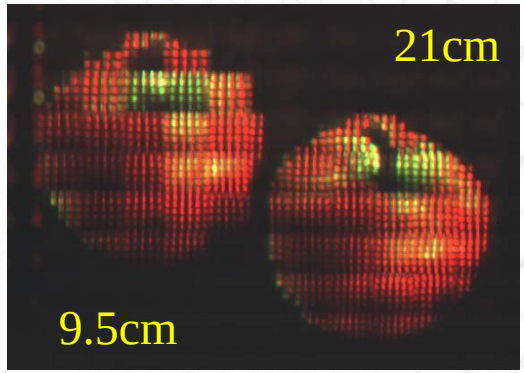
J.-H. Park, S. Jung, H. Choi , and B. Lee, *Opt. Express*, vol. 11, no. 16, pp. 1862-1875, 2003.

Experimental Results

Conventional InIm

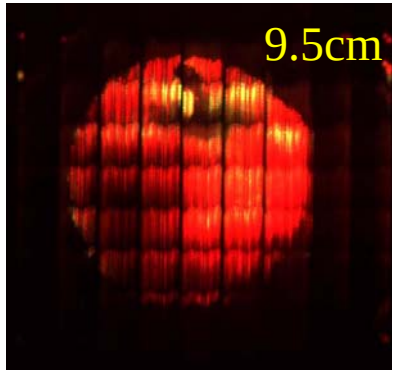


▪ Focused at **9.5**cm

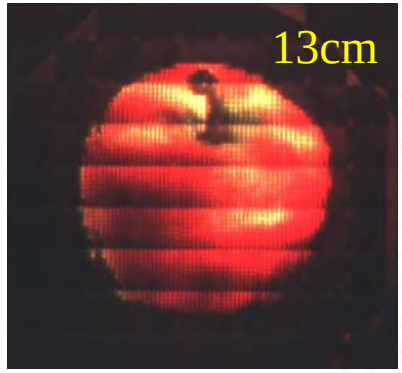


▪ Focused at **21**cm

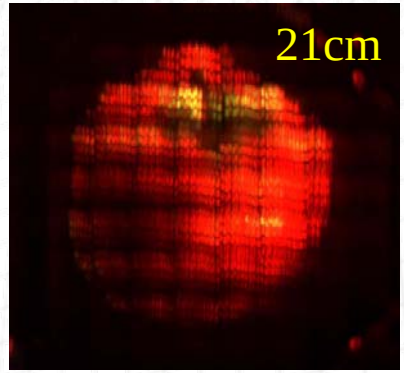
Proposed method



▪ Extraordinary horizontal mode

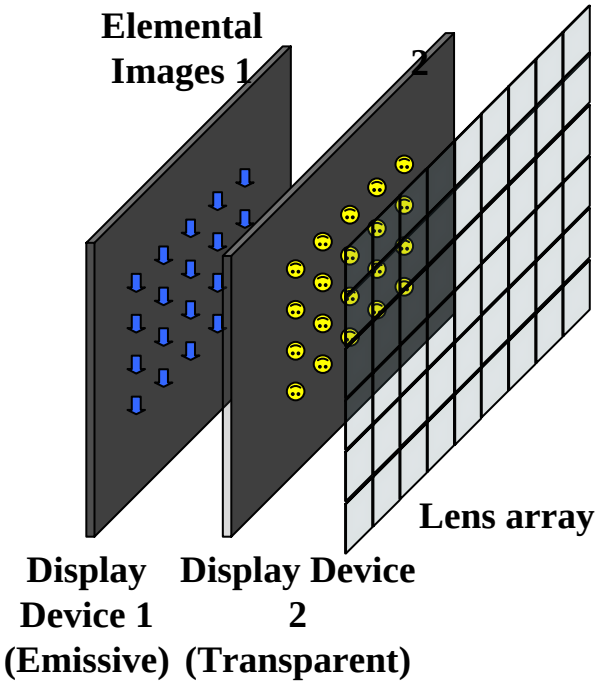


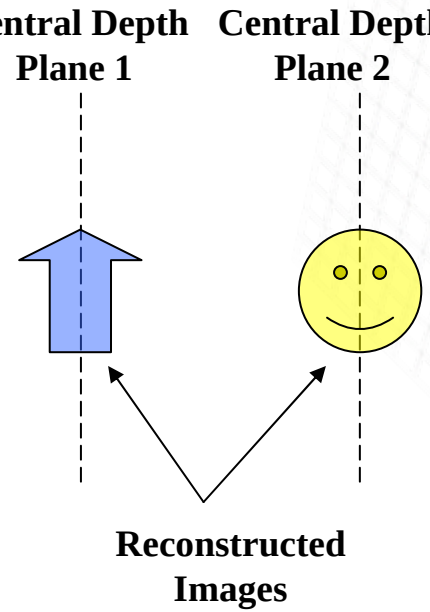
▪Ordinary mode



▪ Extraordinary vertical mode

Depth enhancement: Layered-panel integral imaging





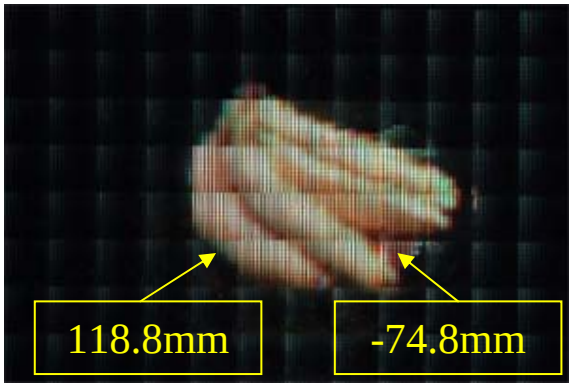
Transparent display device

$$\frac{1}{g}+\frac{1}{l_c}=\frac{1}{f}$$

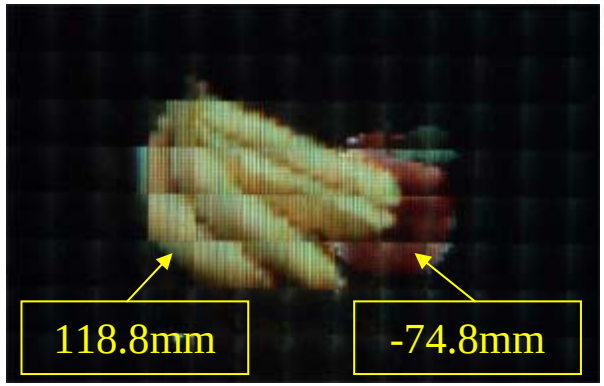
H. Choi, Y. Kim, J.-H. Park, J. Kim, S.-W. Cho, and B. Lee, *Opt. Express*, vol. 13, no.15, pp. 5769-5776, 2005.

Experimental results – Proposed scheme

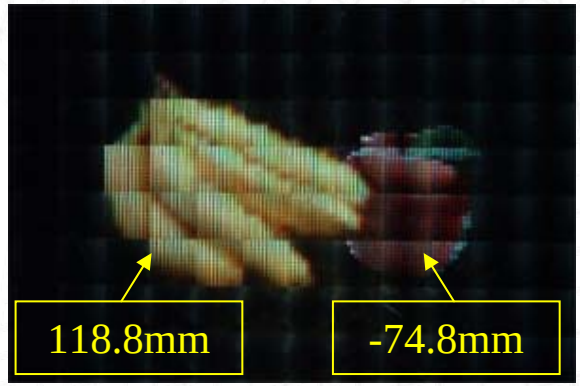
Left Viewpoint



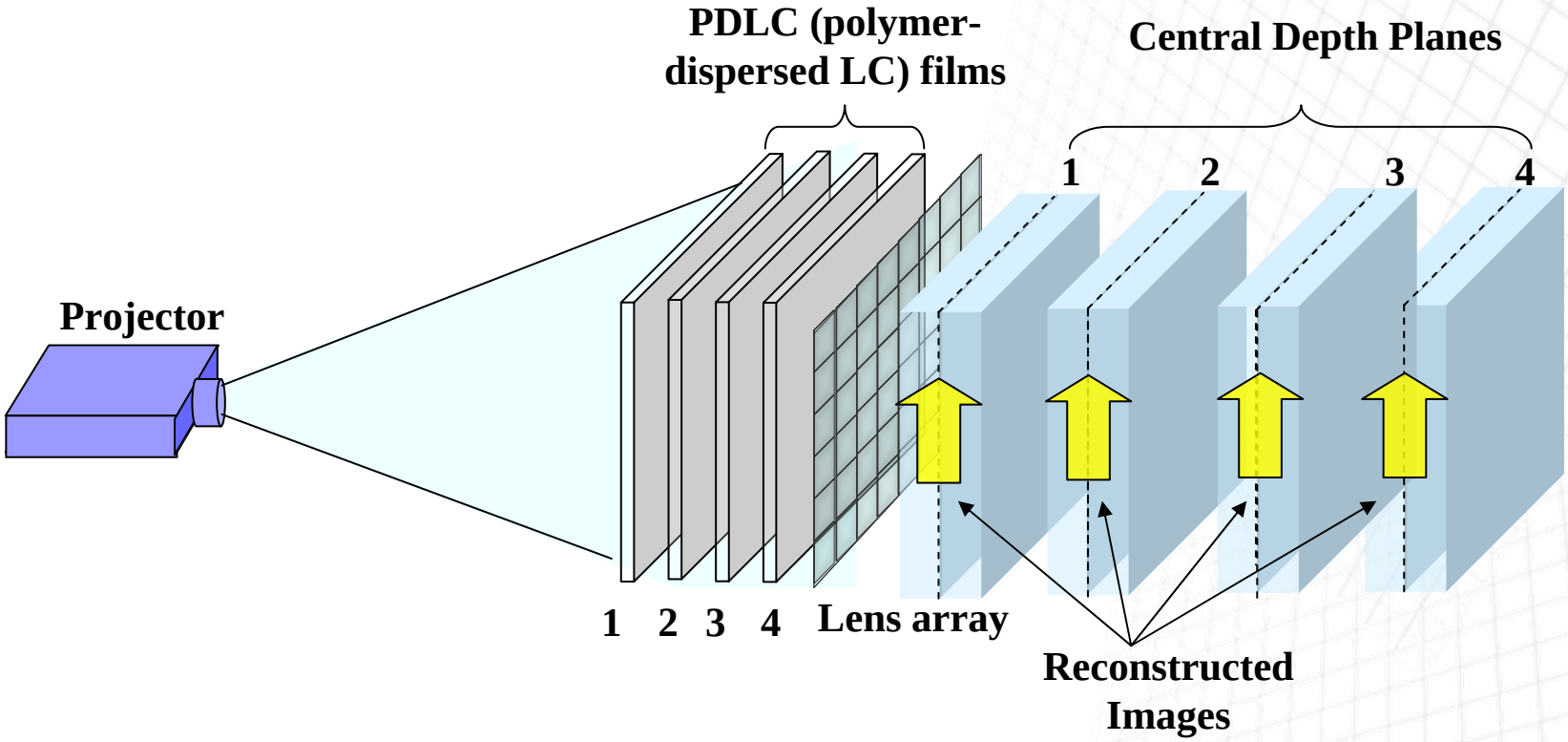
Center Viewpoint



Right Viewpoint

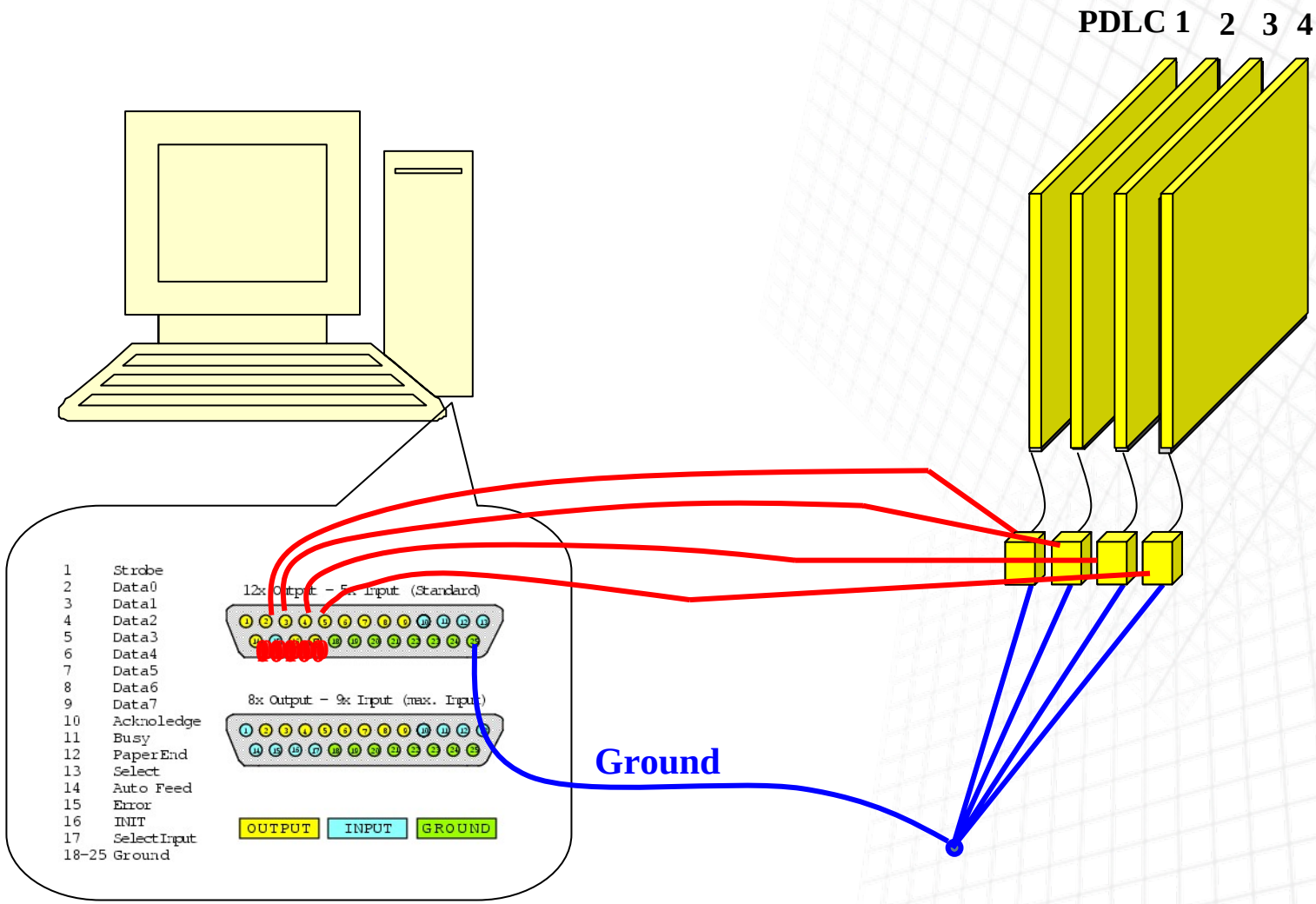


Multi-layered integral imaging: Projection type

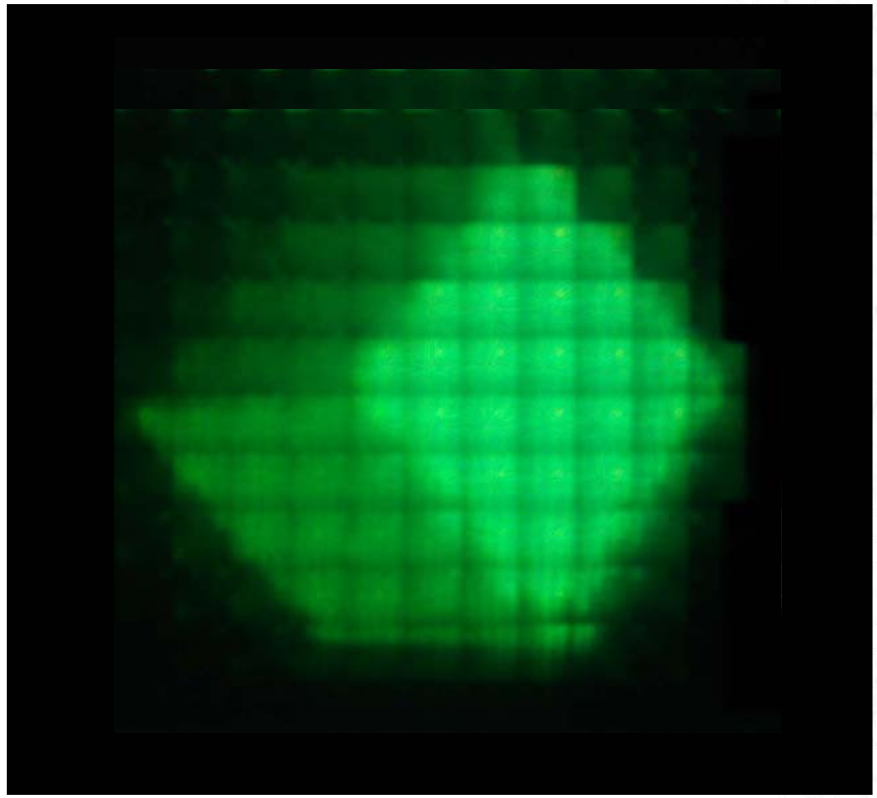


- No polarization sheet is needed!

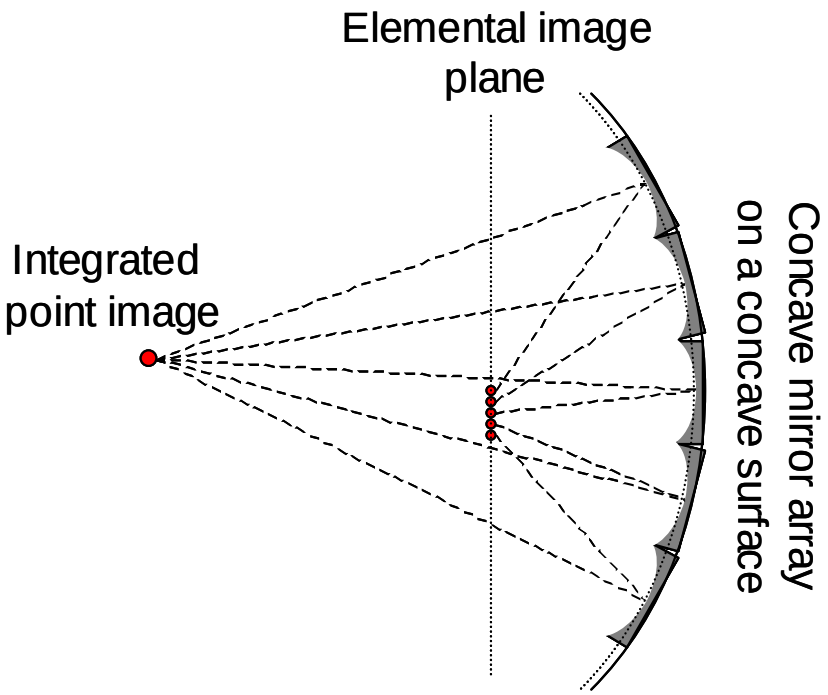
PDLC control

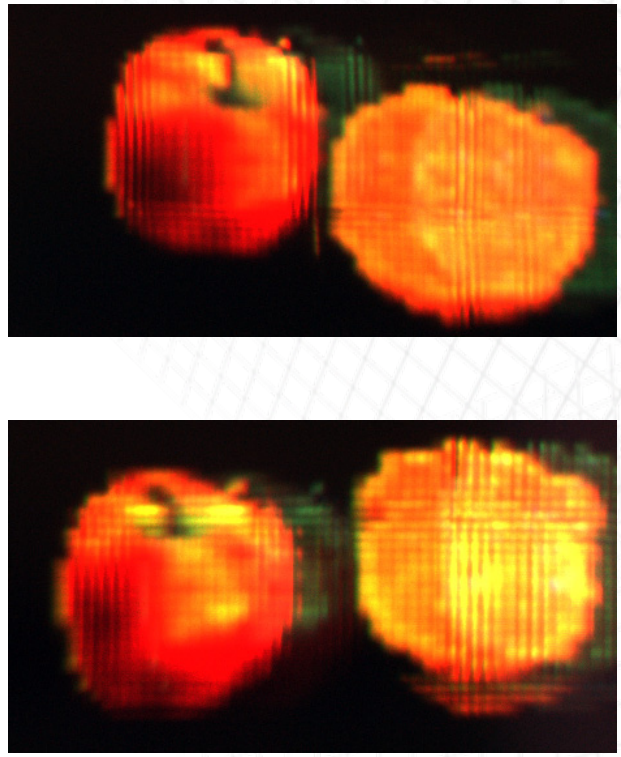


Multi-layered integral imaging



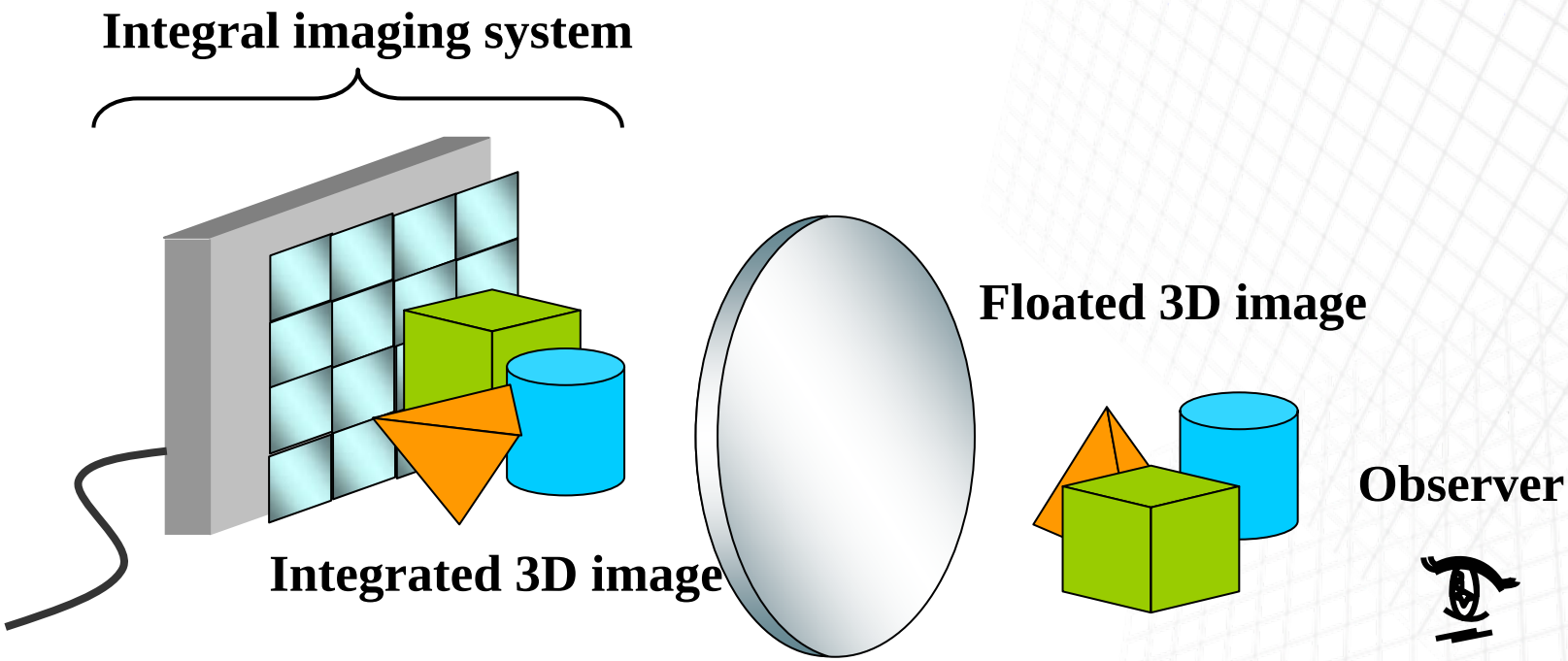
Projection-Type Integral imaging(1)





Y. Jeong, S. Jung, J.-H. Park, and B. Lee, "A reflection-type integral imaging scheme for displaying three-dimensional images," Optics Letters, vol. 27, no. 9, pp. 704-706, 2002.

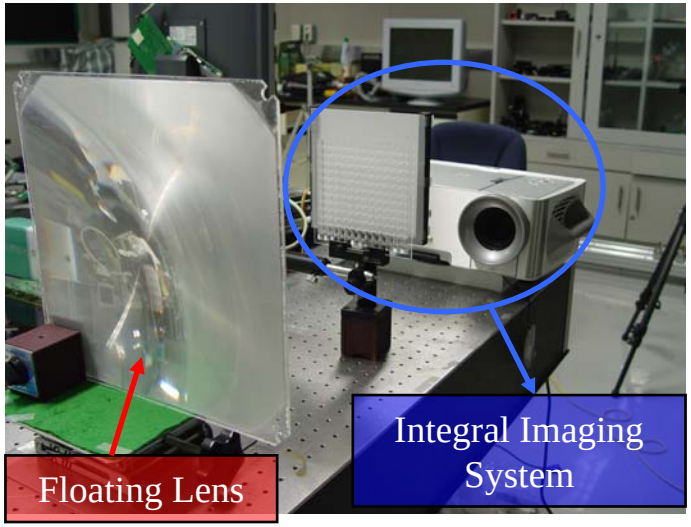
Projection-Type Integral imaging(2)



S.-W. Min, M. Hahn, J. Kim, and B. Lee, "Three-dimensional electro-floating display system using an integral imaging method," Optics Express, vol. 13, no. 12, pp. 4358-4369, 2005.

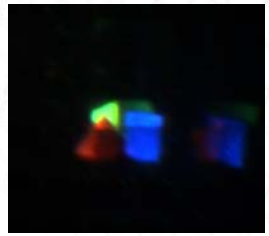
Integral Floating Imaging

• **Experimental setup**



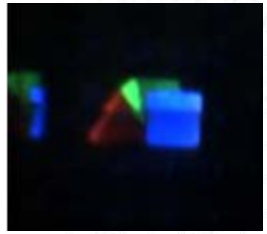
• **Viewing angle**

Center

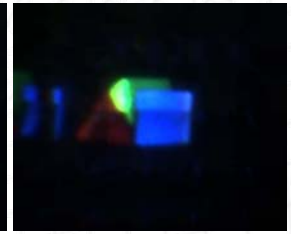


Left 10º

Left 8º

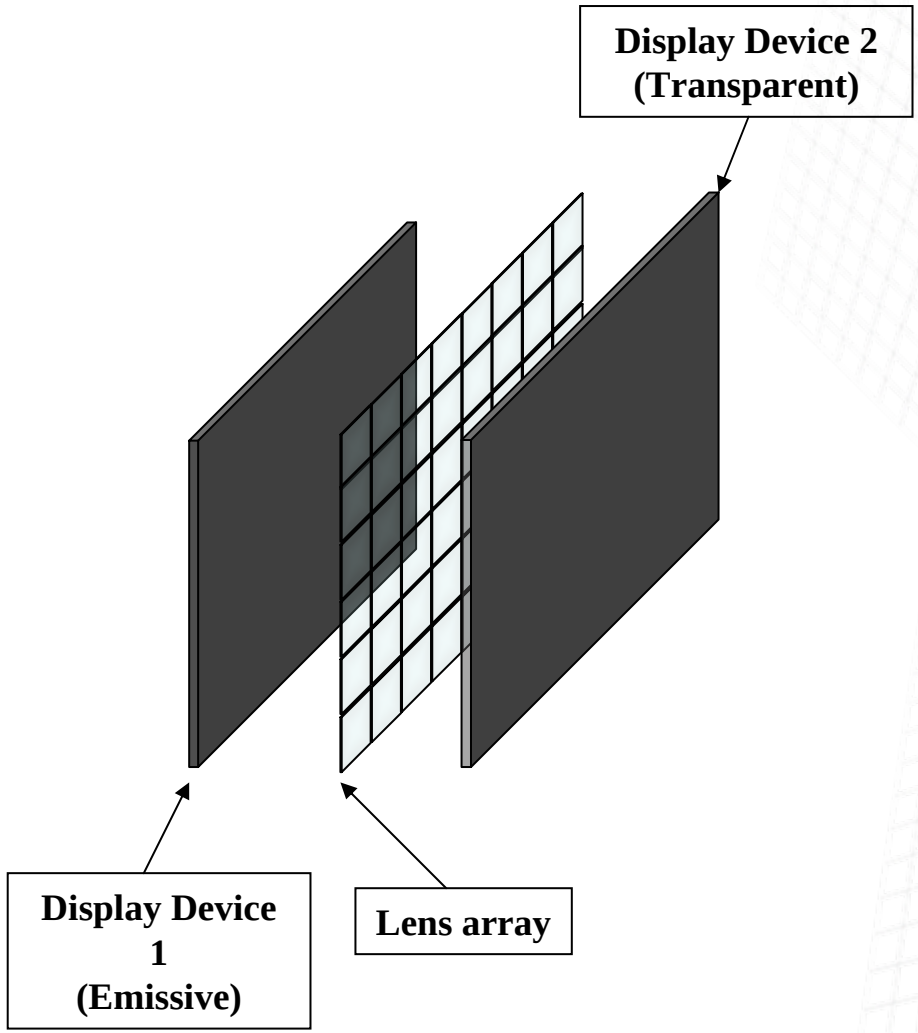


Right 8º

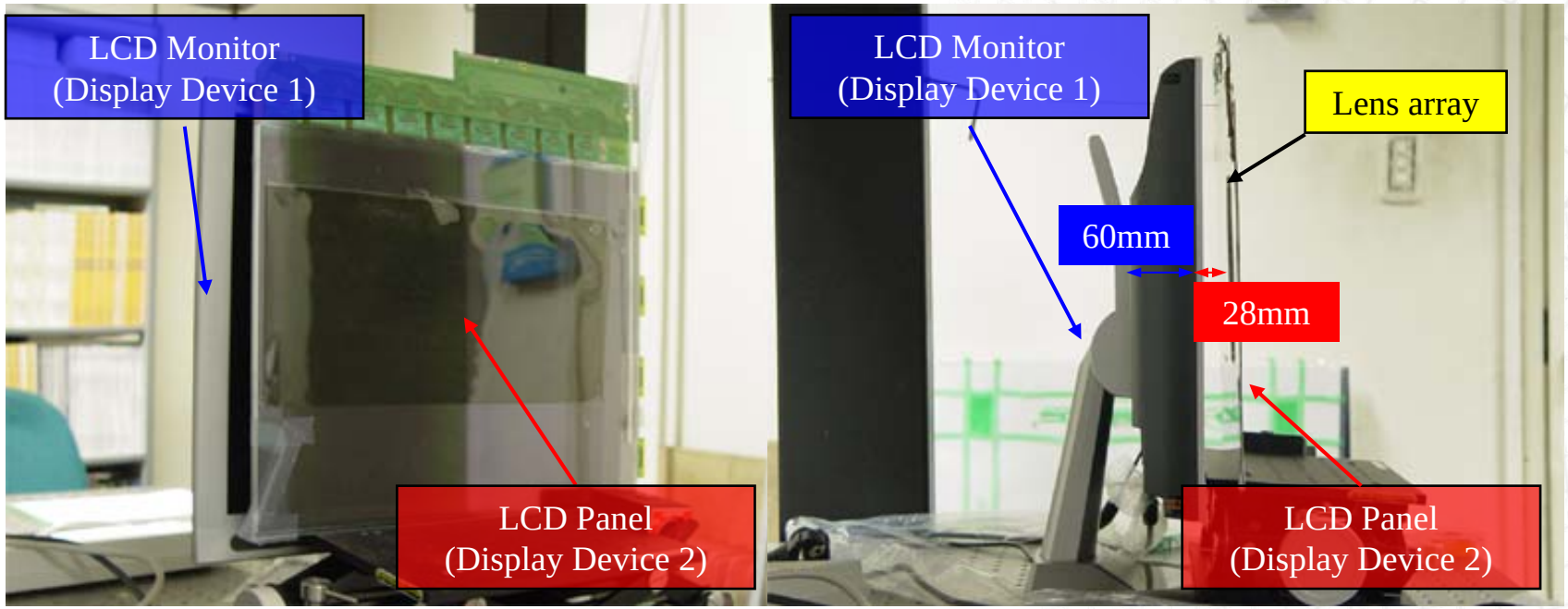


Right 10º

3D/2D convertible integral imaging: Using two panels



Experimental setup

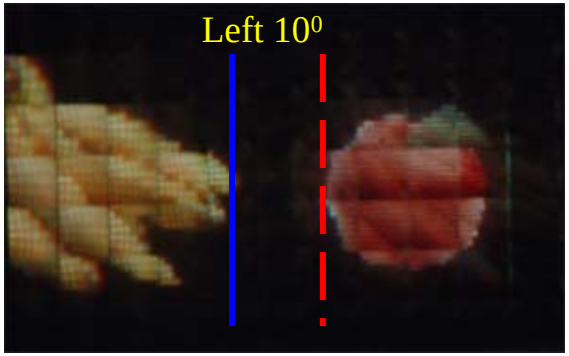


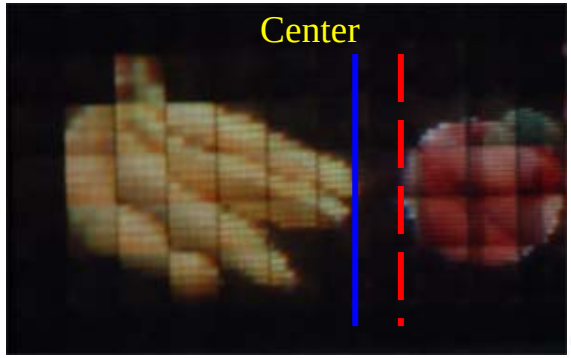
H. Choi, J.-H. Park, J. Kim, S.-W. Cho, and B. Lee, "Wide-viewing-angle 3D/2D convertible display system uing two display devices and a lens array," Optics Express, vol. 13, no. 21, pp. 8424-8432, 2005.

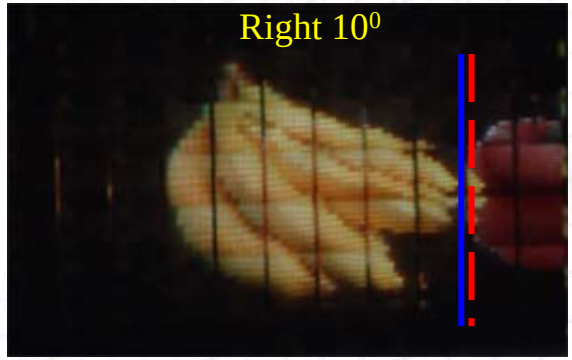
Experimental result

2D mode

3D mode

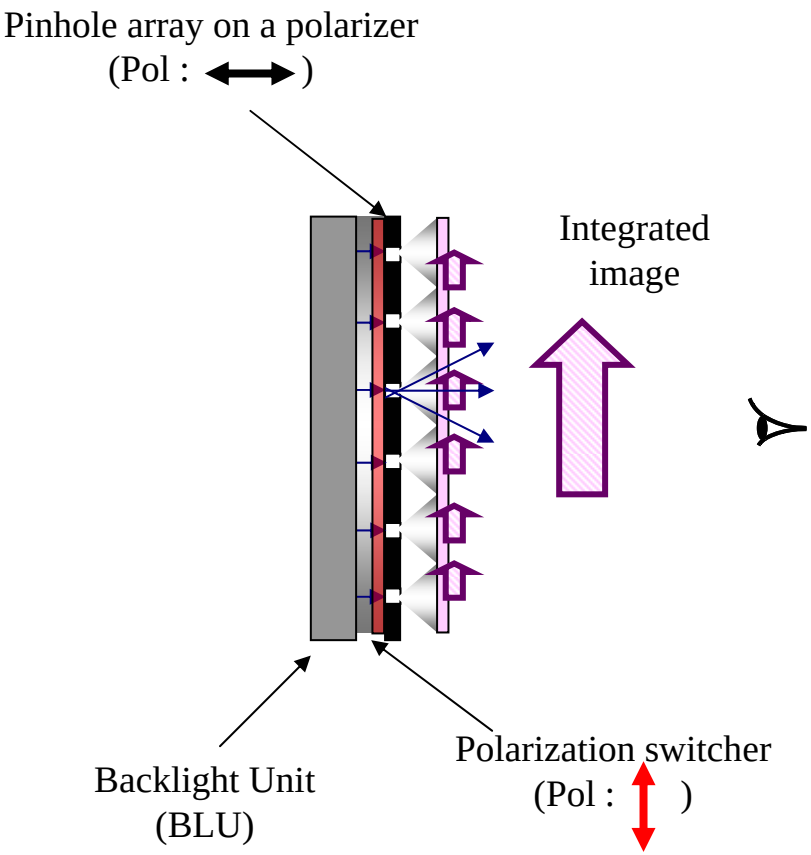




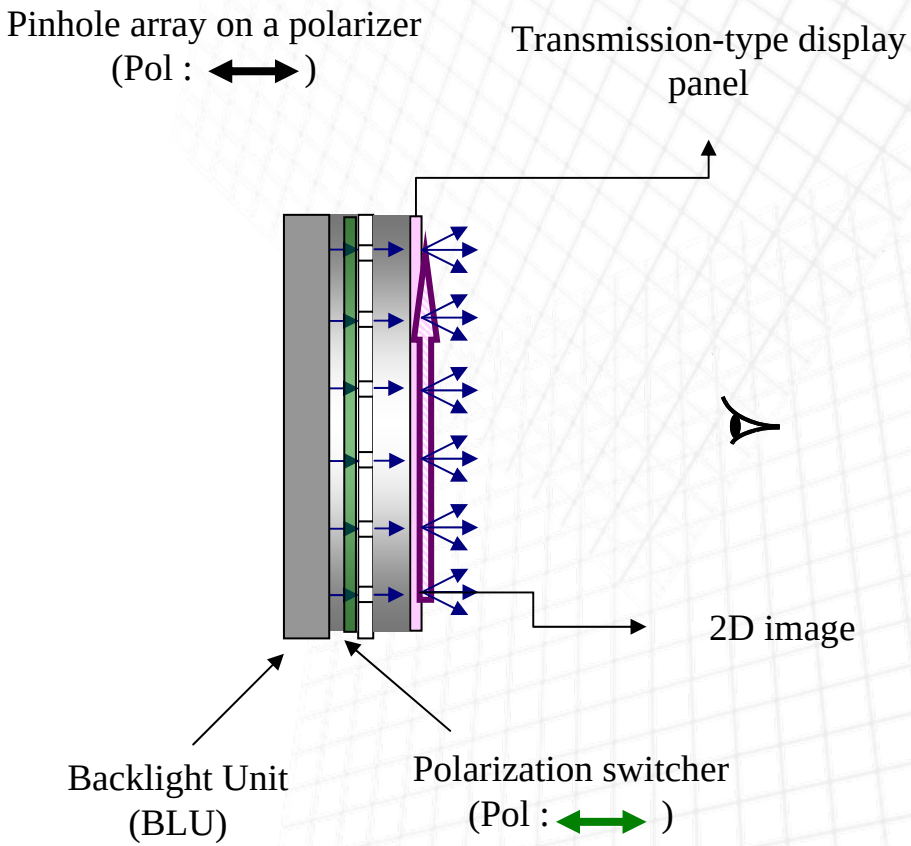


3D / 2D convertible integral imaging: Using pinhole array

3D mode

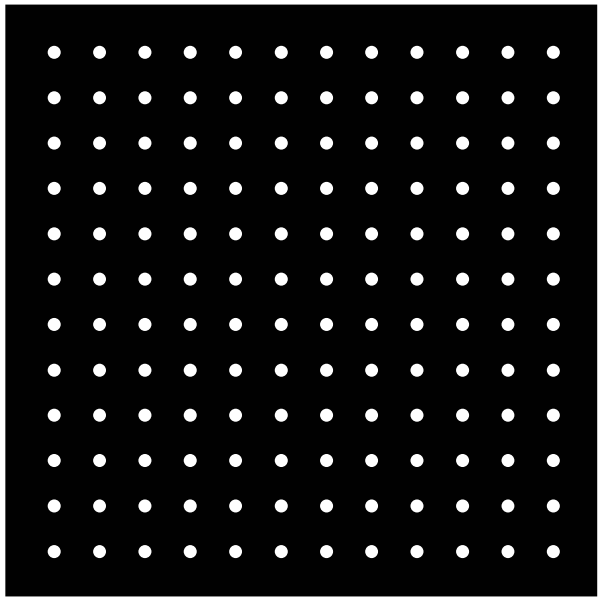


2D mode

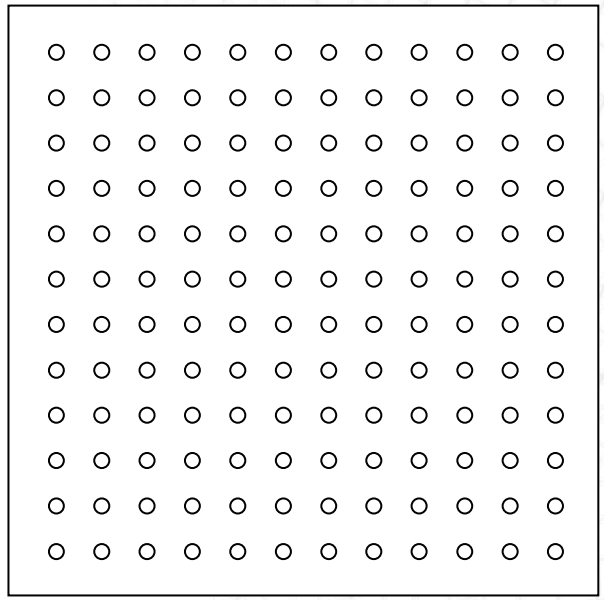


Pinhole array on a polarizer

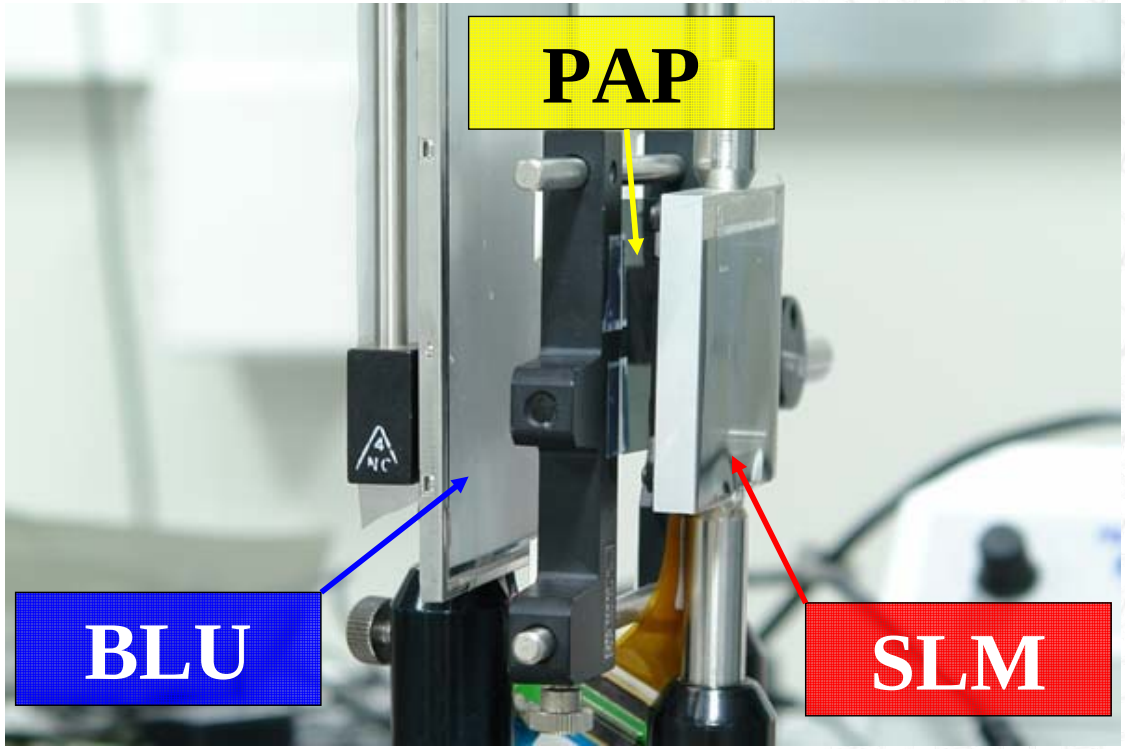
- **3D mode**
  (orthogonal polarization)



- **2D mode**
  (parallel polarization)



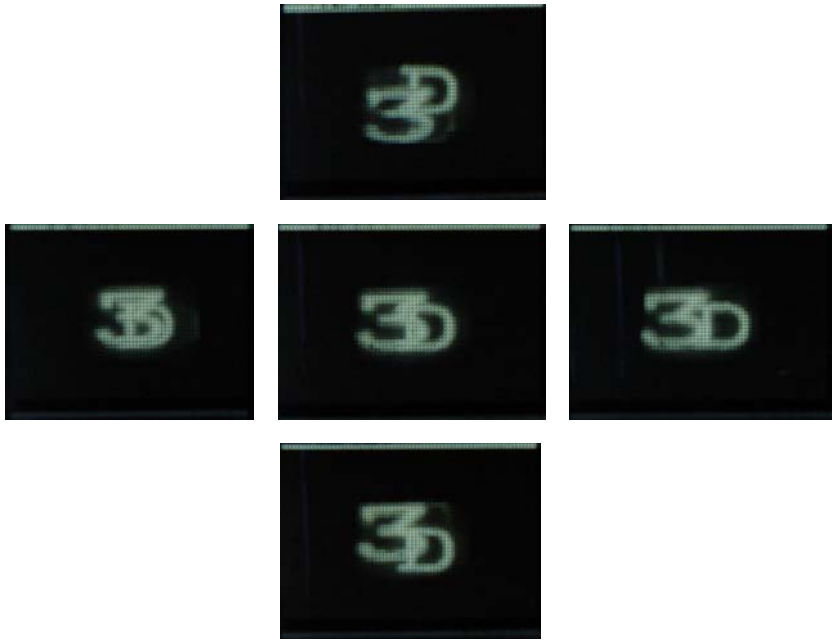
Experimental setup



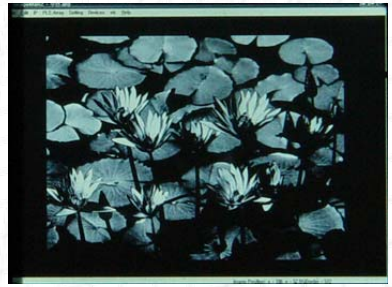
H. Choi, S.-W. Cho, J. Kim, and B. Lee, “A thin 3D-2D convertible integral imaging system using a pinhole array on a polarizer,” Optics Express, vol. 14, no. 12, pp. 5183-5190, 2006.

Experimental results

- 3D mode



- 2D mode



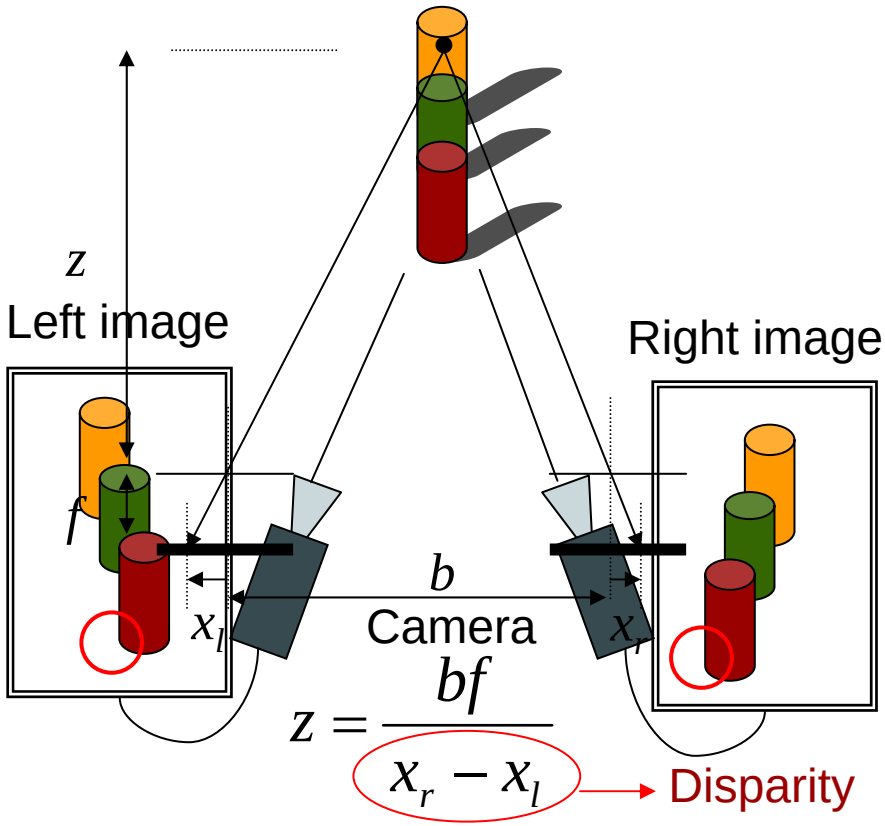
2D/3D Mixed Mode

❖ **Virtual Shopping mall**

상의와 하의, 신발, 머리 모양 등 2차원으로 표시된 데이터를 선택하여 3차원 가상 모델이 착용해 볼 수 있도록 하였다.

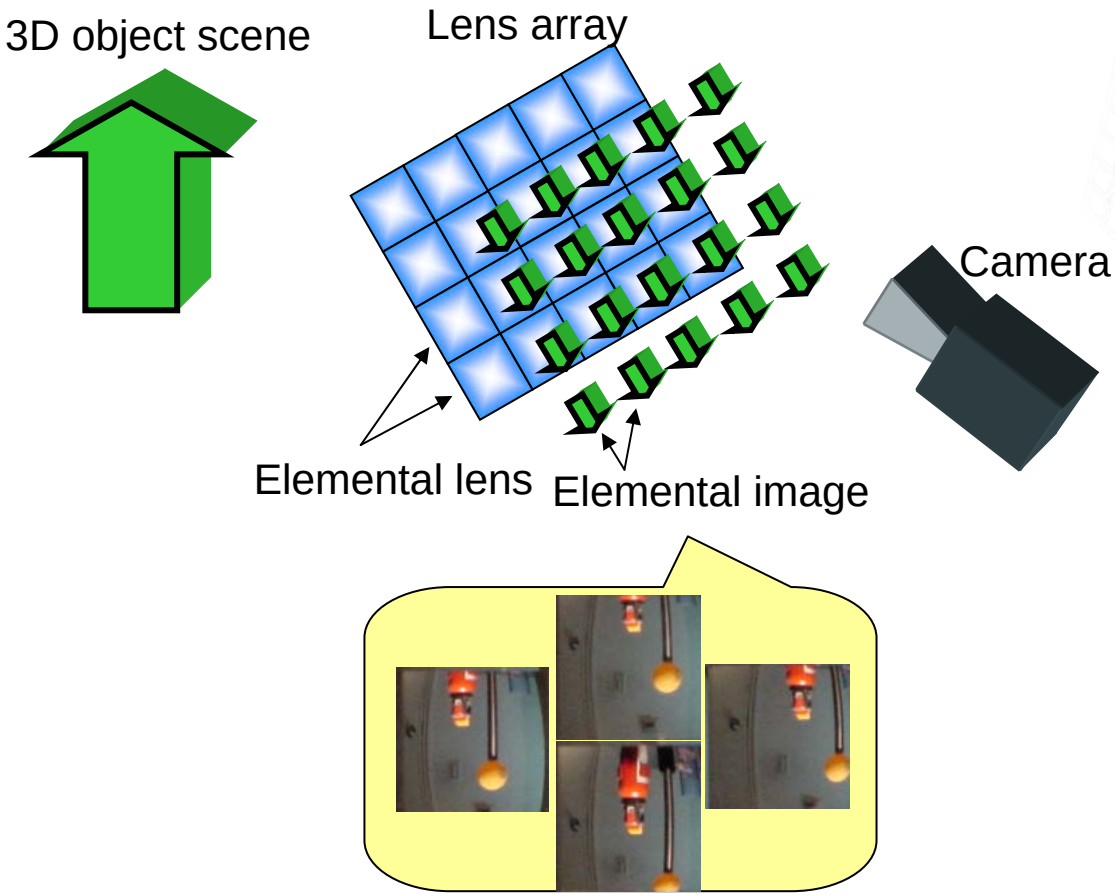
Depth extraction from planar images

Multi-camera method ⇨ Extract 3D information from two or more perspective images



- Camera modeling
- **Image acquisition**
- Feature extraction
- Correspondence analysis
- Post-processing
- Disparity acquisition
- 3D depth recovery

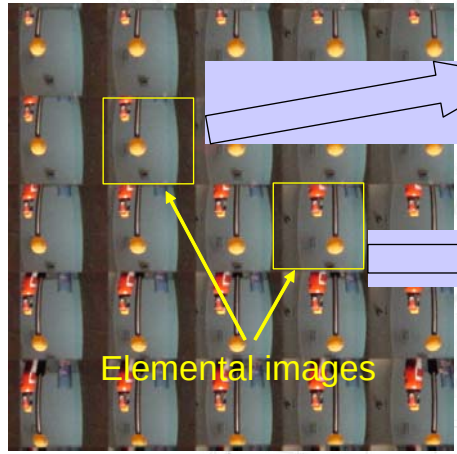
Depth extraction using elemental image

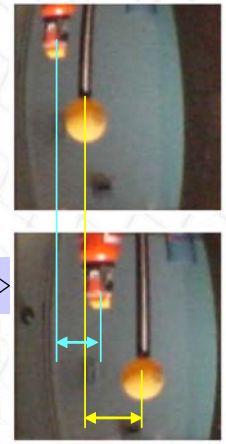


- Lens array modeling
- Image acquisition
- Feature extraction
- Correspondence analysis
- Post-processing
- Disparity acquisition
- 3D depth recovery

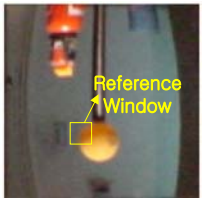
Experimental result

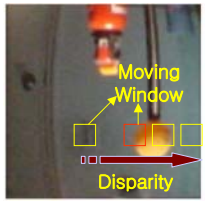
- Lens array: φ=15 mm, f=40 mm, Spherical

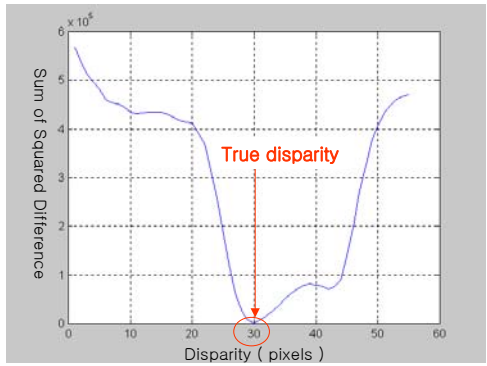


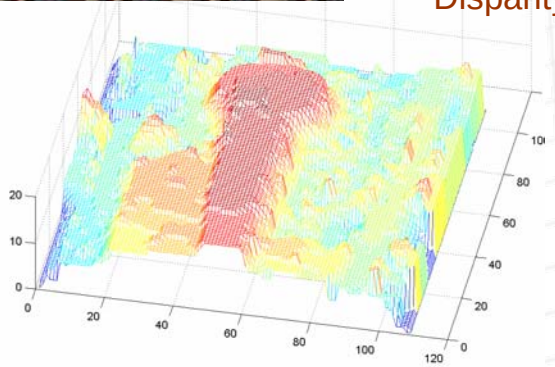


Disparity

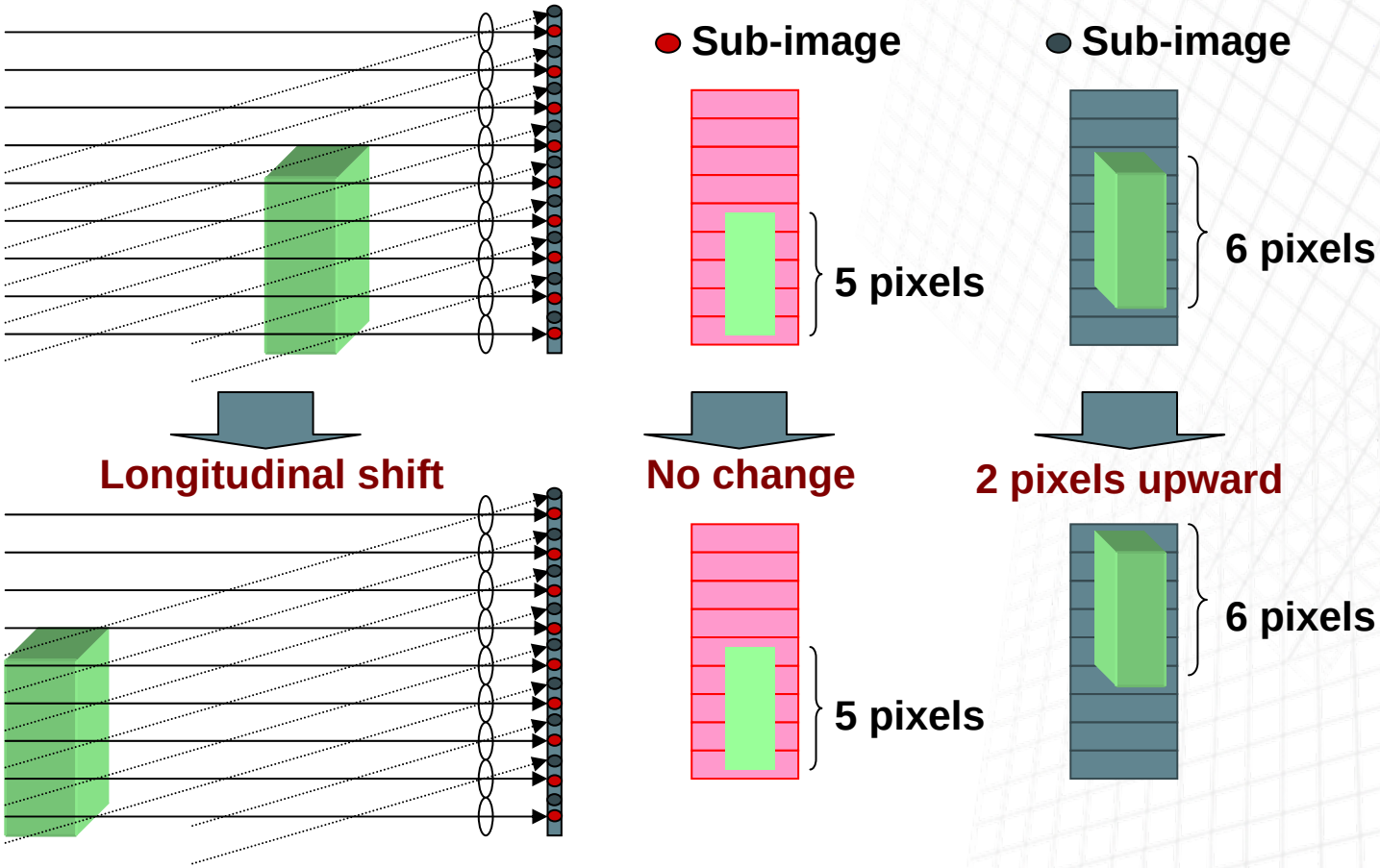






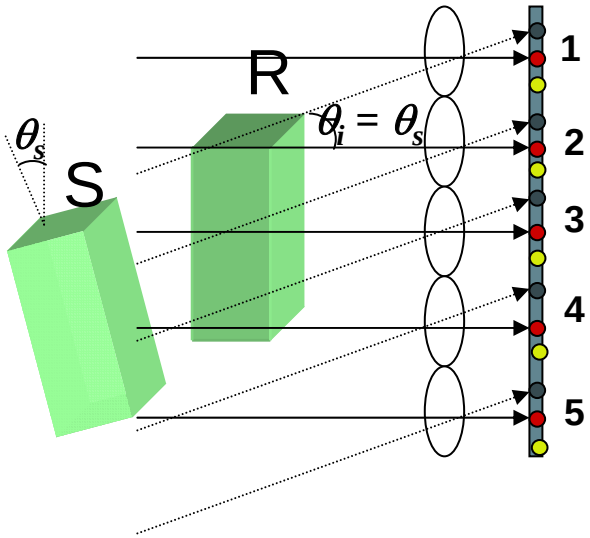


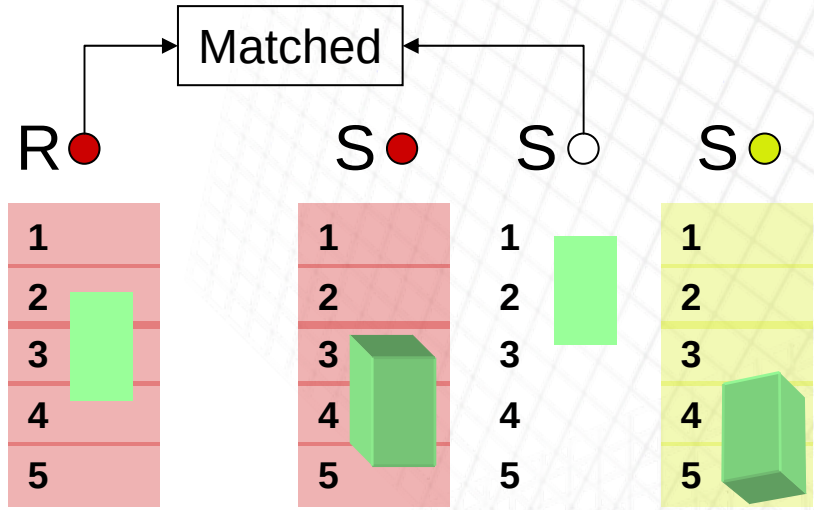
Scale invariance



W/ out-of-plane rotation

- Pixel of center sub-image
- Pixel of *i*-th (θ_i) sub-image
- Pixel of j-th (θ_j) sub-image





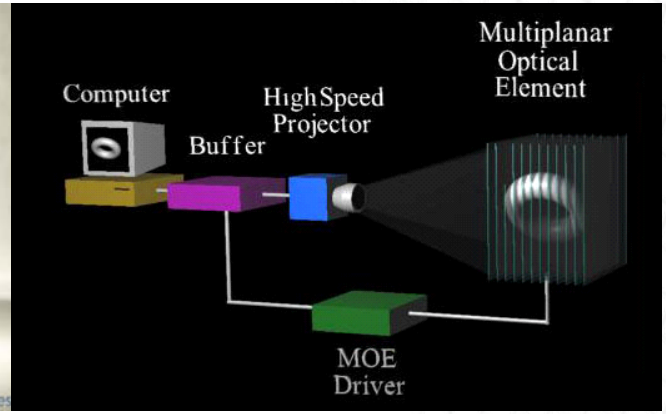
$$\Delta u_{i,i+rotation} = \frac{(x_s - x_r) + z_s \tan(\theta_{rotation} + \theta_i) - z_r \tan\theta_i}{\varphi}$$

1. Find matched pair with center view of reference and oblique views of signal → Out-of-plane rotation angle
2. Same procedure with previous case considering out-of-plane rotation angle → Transverse & longitudinal position

3차원 디스플레이의 최근 기술

Autostereoscopic **방식**
Holography
집적 영상 방식
Volumetric **방식과 그 외**

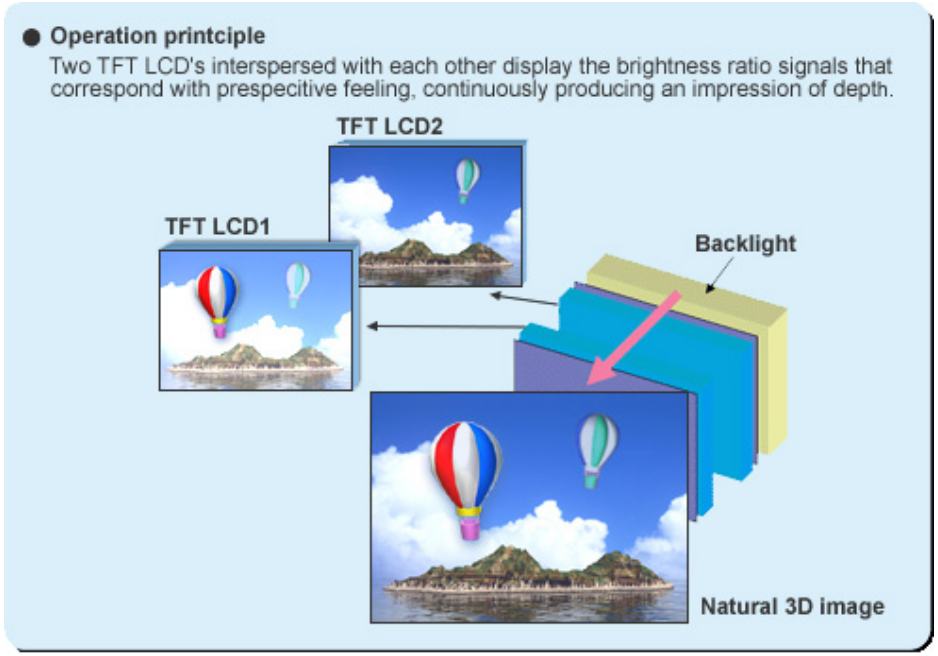
DepthCube



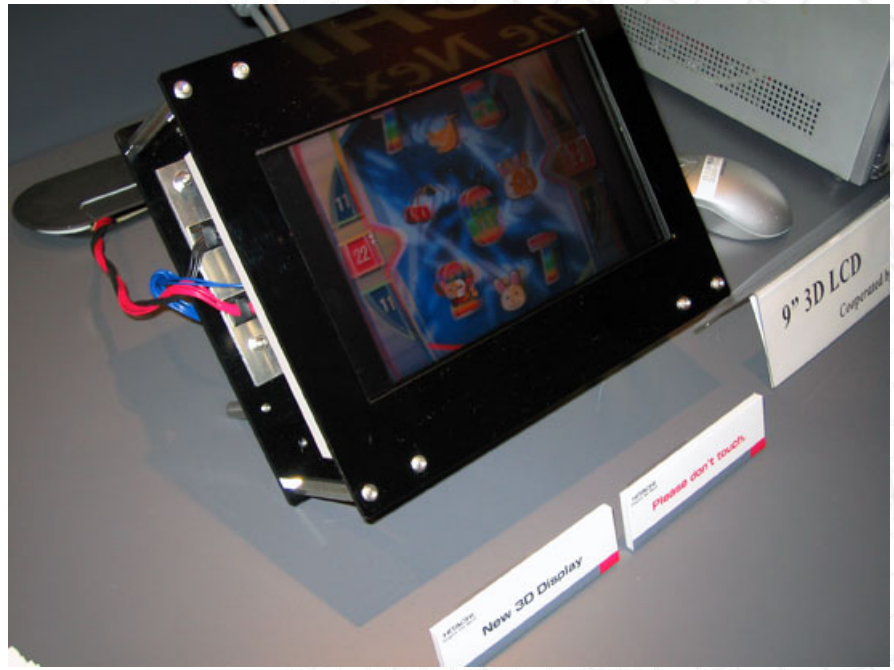
Resolution	**1024×748×20**
Physical voxel count	**15.3 Million**
Perceived voxel count	**465.7 Million**
Color depth	**15 bit**
Refresh rate	**50 Hz**
Update rate	**20 Hz**
Image volume	**15.6”×11.8”×4.1”**

[Light Space]

Depth-fused 3-D Display



[Hitachi]



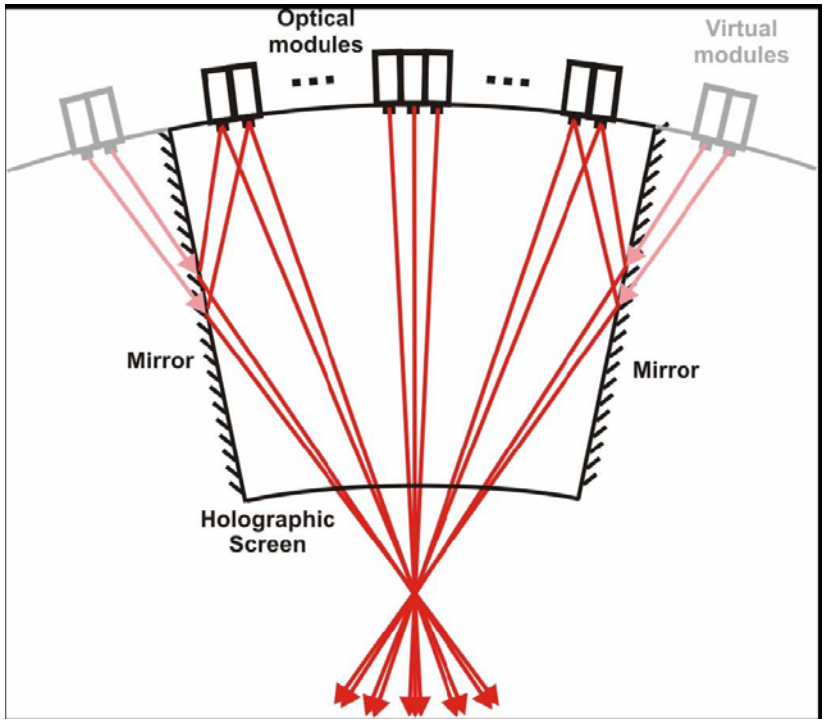
Major features/targets

(1) Data amount is only 1.3 times larger than that of traditional 2D version display.

(2) Compact design where two TFT's are just layered. Target market: Entertainment, on-vehicle applications

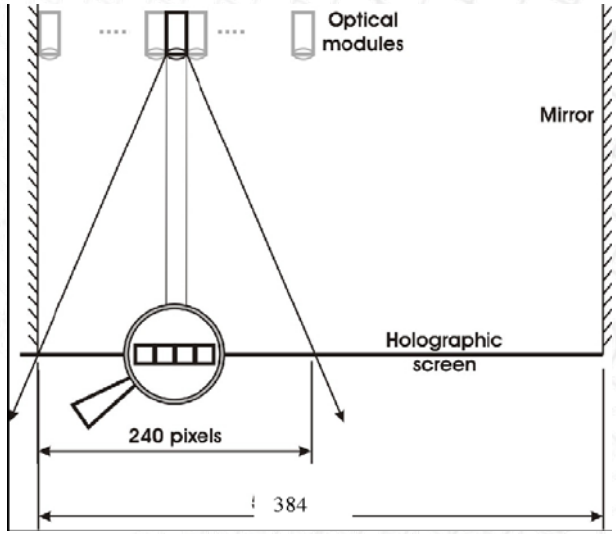
[Major specification]	9 inch wide high-definition LCD
Pixels	800(horizontal RGB)×480(vertical)
Brightness	200 cd/m^2
Color reproducibility	45%(Compared with NTSC)

Holografika

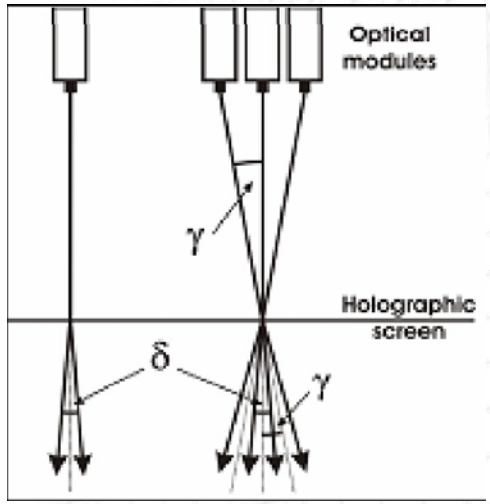


Schematic diagram. A large number of light beams can create a spatial point

(a)



(b)



(a) Optical arrangement

(b) Holographic screen

Holografika

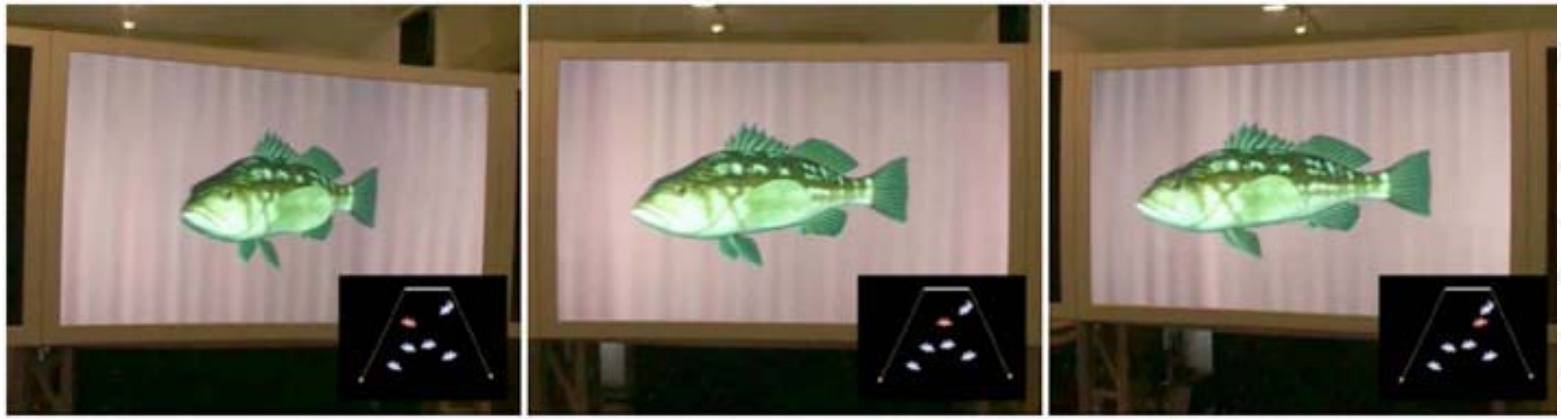
Technical Specification

Specifications	**HoloVizio 640RC**

Aspect ratio	**16:9**
Screen size	**72” diagonal, 1600mm x 900mm**
3D resolution	**50.3 Mpixel**
Input signal	**Up to Dual Gigabit Ethernet**
Compatibility	**PC and WorkStation**
Signal cable	**Ethernet (RJ-45)**
Viewing angle	**50-70 degrees**
Color	**16 M (24 bit RGB)**

Dimensions (W x H x D)	**2697mm x 2136mm x 2829mm**
The frequency of the power network	**50 Hz ... 60 Hz**
Nominal voltage level(s)	**230/400 V, 115/200 V**
Power consumption (using projectors with lamps)	**230/400V approx. 3x30A 115/200V approx. 3x60A 5-wire TNS system**
Dissipated heat (using projectors with lamps)	**Approx. 12 kW**
Power consumption (using projectors with LEDs)	**230/400V approx. 3x16A 115/200V approx. 3x32A 5-wire TNS system**
Dissipated heat (using projectors with LEDs)	**Approx. 5 kW**
Temperature	**+5° C...+40° C**
Relative humidity	**Max. 80% / 50%**
Usage	**Indoor**

Holografika



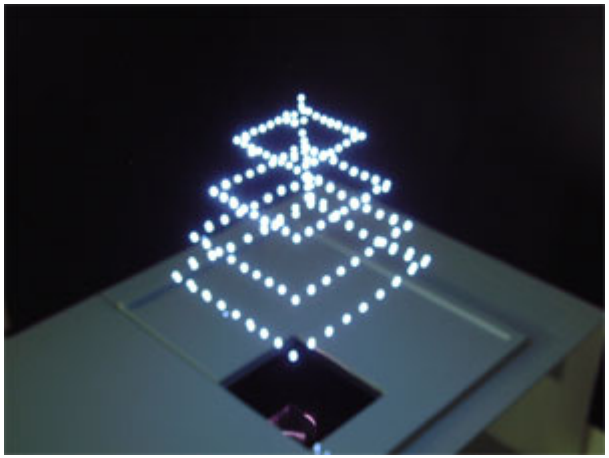
• Images taken from different positions

(a) OpenGL "gears" application

(b) Visualization of an abdominal aortic aneurysm reconstructed from CT data

- Each view of the 3D image comes from multiple modules
- Smooth and continuous transition between views

Three dimensional images in the air



A 3D-object displayed using a 3D-image spatial drawing device

when laser beams are strongly focused, air plasma emission can be induced only near the focal point. The device creates “real” 3D images by using laser light, which is focused through a lens at points in space above the device, to create plasma emissions from the nitrogen and oxygen in the air at the point of focus.

The emission time of the laser pulse light is on the order of a nano-second (10-9 sec).
The device uses 1 pulse for each dot to that the human eye can recognize plasma emission by utilizing the after-image effect, and enables a 100 dot/sec display.

The National Institute of Advanced Industrial Science and Technology (AIST, President: Hiroyuki Yoshikawa) and Keio University (President: Yuichiro Anzai), in collaboration with Burton Inc. (CEO: Hidei Kimura),

[AIST press 2006. 2]

Actuality system

The Perspecta Spatial 3-D System v1.9 creates 10’’ diameter three-dimensional imagery.

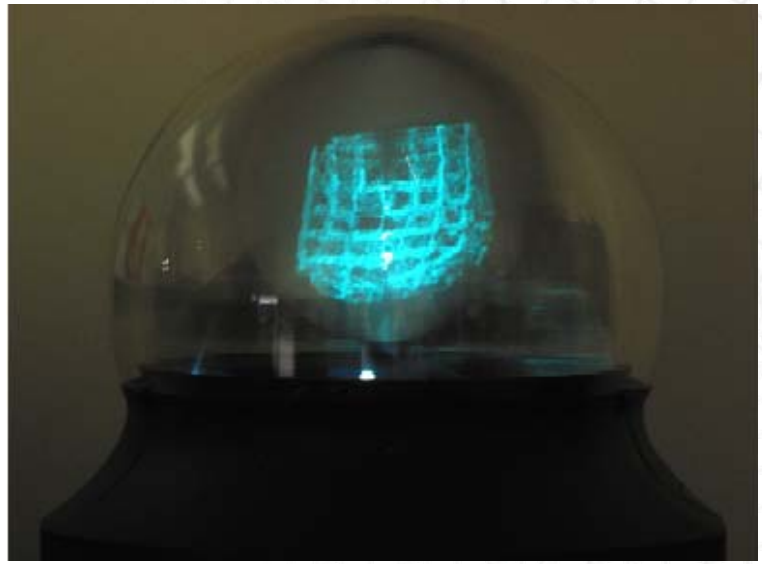
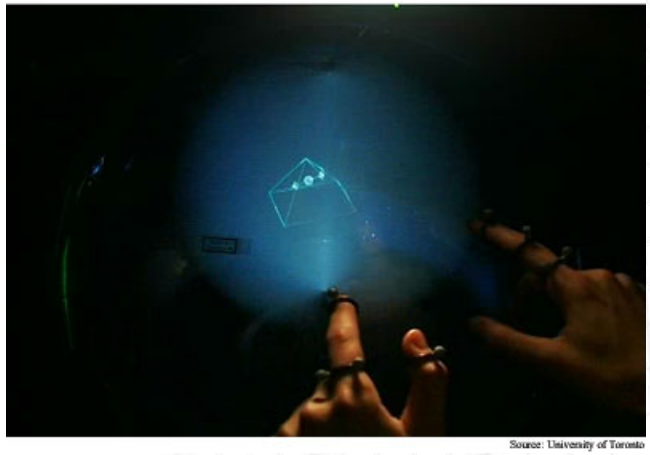


Image Size: 10” (25 cm)-diameter Spatial 3-D imagery
Field of View: 360º horizontal, 270º vertical
Resolution: 198 slices (~1 slice / degree), 768 x 768 pixels / slice
Dimensions: 48” high x 31” wide x 22.25” deep

Multi-Finger Gestural Interaction with 3D Volumetric Displays



Source: University of Toronto

University of Toronto: direct gestural interaction with virtual objects contained in a volumetric display.

Using fingers to gesture in the space around and on the surface of the volumetric display. The user's finger positions and postures are tracked by a set of four cameras.

Conclusion

- 3D display technique is demanded by rapid growing IT industry.
- Various 3D display techniques have been devised in both categories of glass-type and glassless-type.
- Innovation in display components is required.
- Potential near applications: Digital signage, 2D/3D DVD, Head-mounted display, …