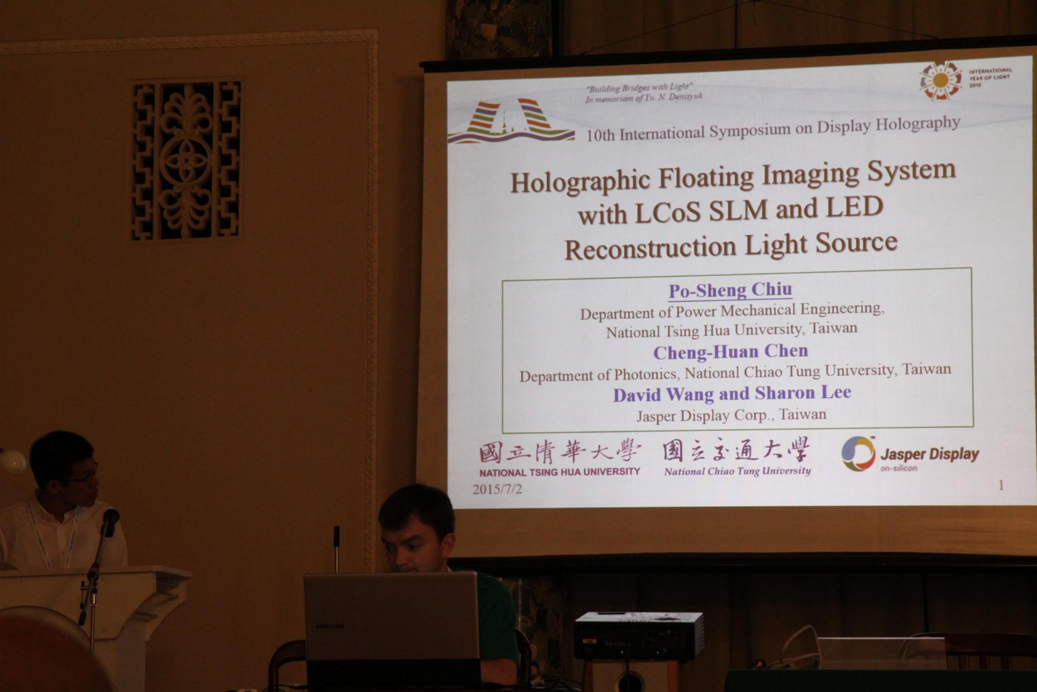
"Building Bridges with Light"
In memoriam of Yu. N. Denisyuk
INTERNATIONAL YEAR OF LIGHT 2015
10th International Symposium on Display Holography
Holographic Floating Imaging System with LCoS SLM and LED Reconstruction Light Source
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Department of Power Mechanical Engineering, National Tsing Hua University, Taiwan
Cheng-Huan Chen
Department of Photonics, National Chiao Tung University, Taiwan
David Wang and Sharon Lee
Jasper Display Corp., Taiwan
國立清華大學
NATIONAL TSING HUA UNIVERSITY
國立交通大學
National Chiao Tung University
Jasper Display
on-silicon
2015/7/2
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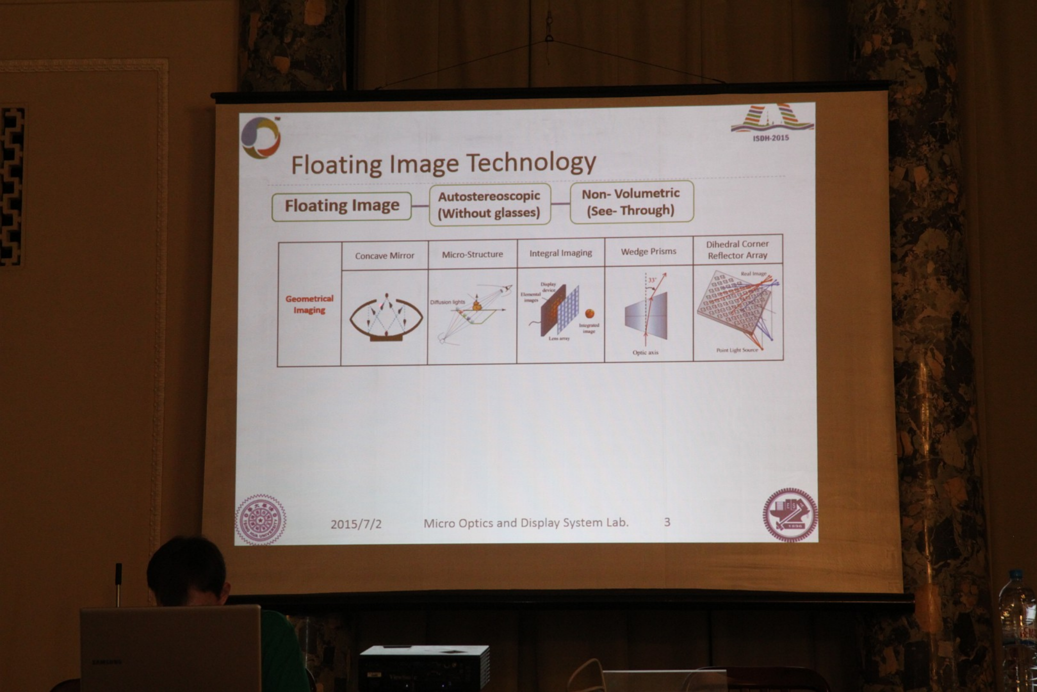
Outline

- Introduction
- Architecture of Floating Imaging System
- LED Reconstruction Light and Pinhole Size
- Image Demonstration
- Conclusions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Floating Image Technology
Floating Image
Autostereoscopic (Without glasses)
Non- Volumetric (See- Through)
Concave Mirror
Micro-Structure
Integral Imaging
Wedge Prisms
Dihedral Corner Reflector Array
Geometrical Imaging
Diffusion lights
Display device
Elemental images
Lens array
Integrated image
33°
Optic axis
Real Image
Point Light Source
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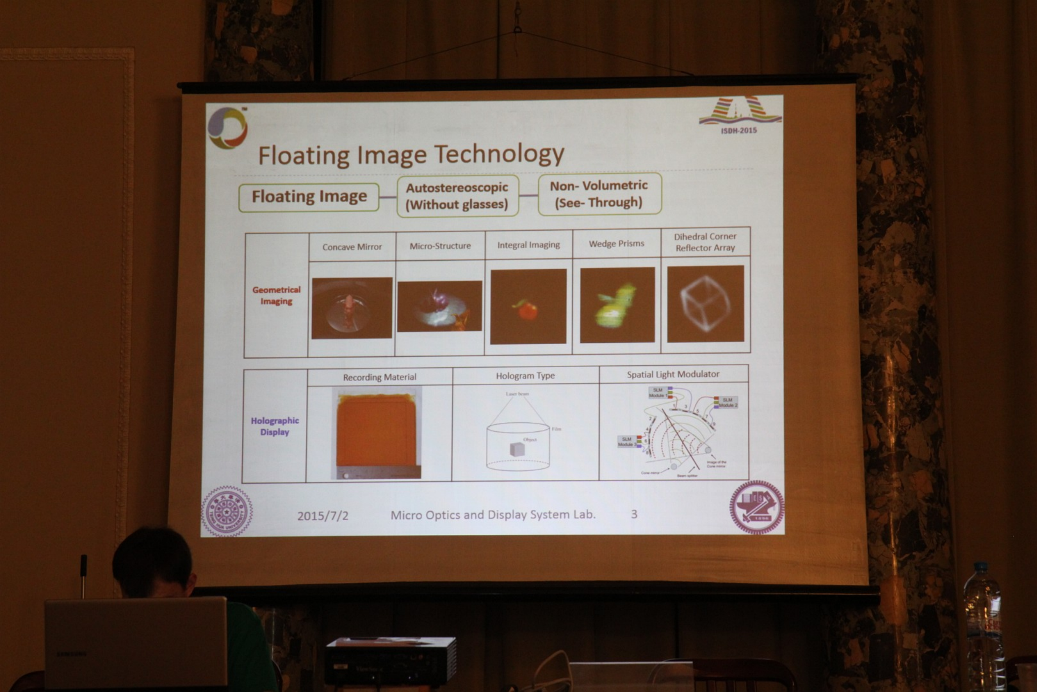
Floating Image Technology

Floating Image — **Autostereoscopic (Without glasses)** — **Non- Volumetric (See- Through)**

	Concave Mirror	Micro-Structure	Integral Imaging	Wedge Prisms	Dihedral Corner Reflector Array
Geometrical Imaging					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Wedge Prisms
Dihedral Corner Reflector Array
Holographic Display
Recording Material
Hologram Type
Spatial Light Modulator
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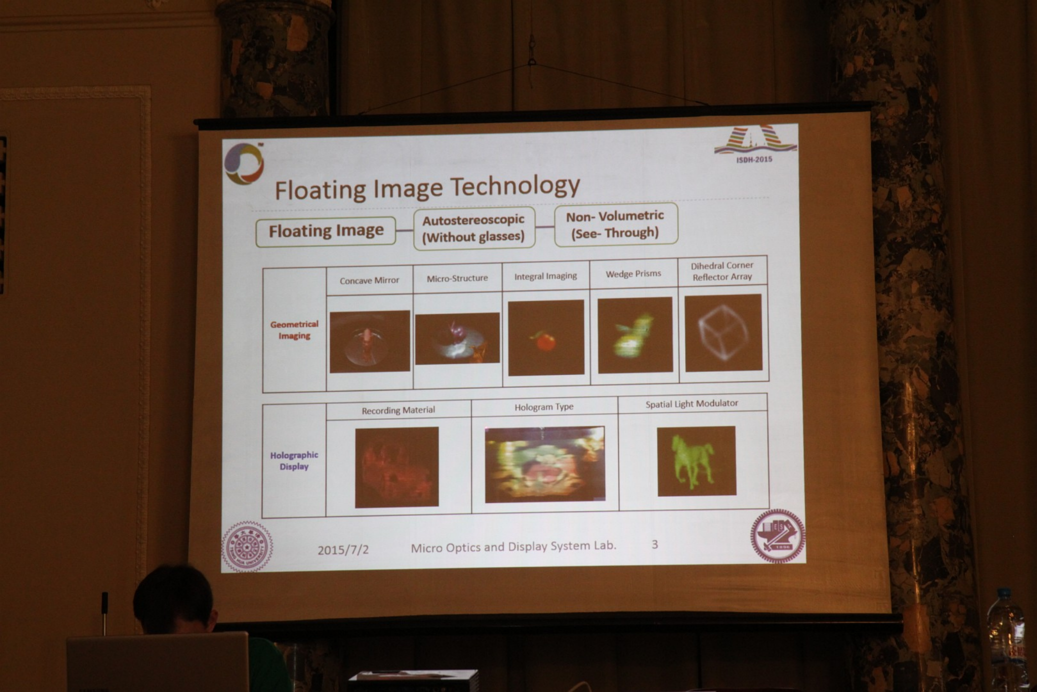
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Holographic Display
Recording Material
Hologram Type
Spatial Light Modulator
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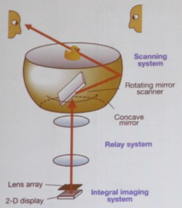
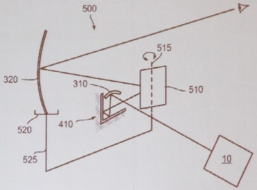
Architecture of Floating Imaging System

Rotational/ Concave mirror



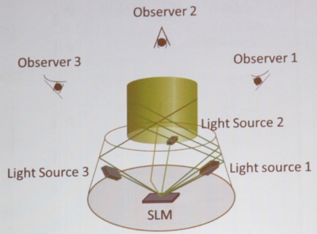
D. Miyazaki, *Proc. SPIE* 9272, 927208-1 (2014).



C. Rotschid et al., US8500284B2 (8/2013).

Architecture of Floating Imaging System

Spatial Light Modulator (SLM)



Holography reconstruction Light Source

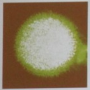
Laser source

Advantages

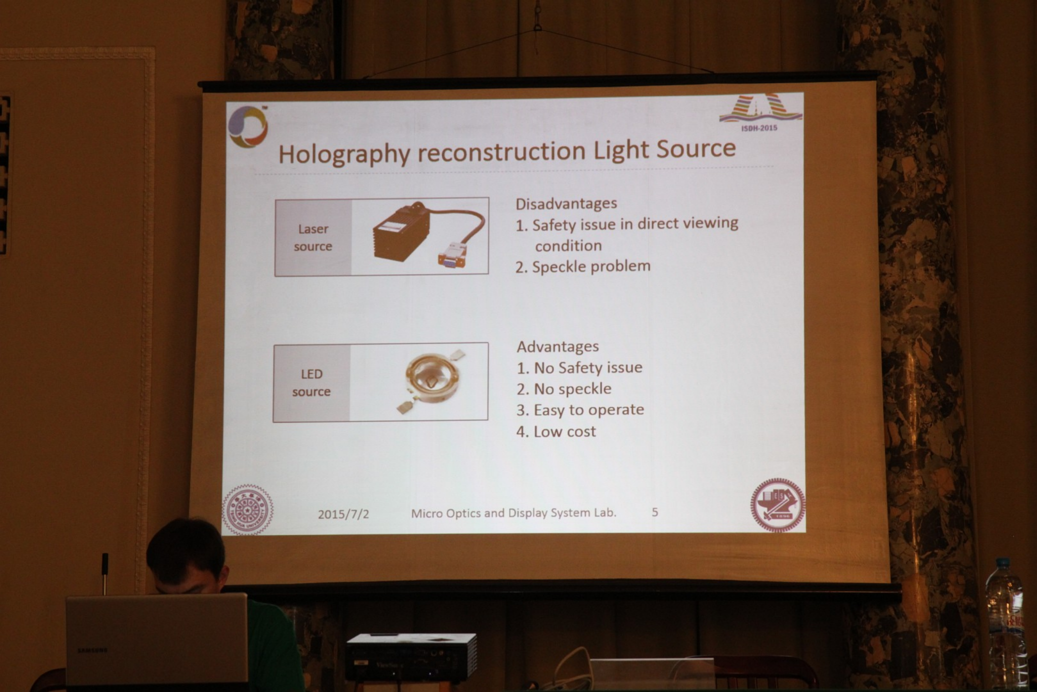
1. High spatial coherence
2. High temporal coherence
3. Highly collimated
4. High power

Holography reconstruction Light Source

Advantages
1. High spatial coherence
2. High temporal coherence
3. Highly collimated
4. High power



Disadvantages
1. Safety issue in direct viewing
   condition
2. Speckle problem


ISDH-2015
Holography reconstruction Light Source
Laser source
Disadvantages
1. Safety issue in direct viewing condition
2. Speckle problem
LED source
Advantages
1. No Safety issue
2. No speckle
3. Easy to operate
4. Low cost
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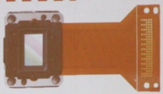
Phase Type LCoS SLM

Phase modulation vs. Amplitude modulation

Jasper Display on-silicon JD 4552 SP55

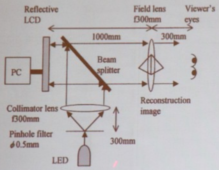
Items for comparison	Phase	Amplitude
Optical efficiency	High	Low
Pixel-pattern relation	One-to-all	One-to-One
Display pattern	Multi-phase picture/pattern	One picture/pattern
Position of image plane	Under software control	Fix by system mechanism



Modulation type	Reflective Phase LCoS
Resolution	1920 x 1080
LC type	VAN
Array dimensions	12.5mm x 7.1mm
Pixel pitch	6.4um
Pixel gap	0.2um
Aperture ratio	≧ 93%
Color field sequential rate	480 Hz

Holographic Display with LED Reconstruction Light Source

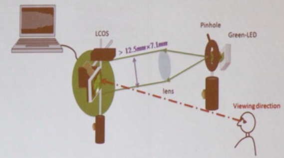
On-axis LED reconstruction



LED pinhole size=0.5 mm

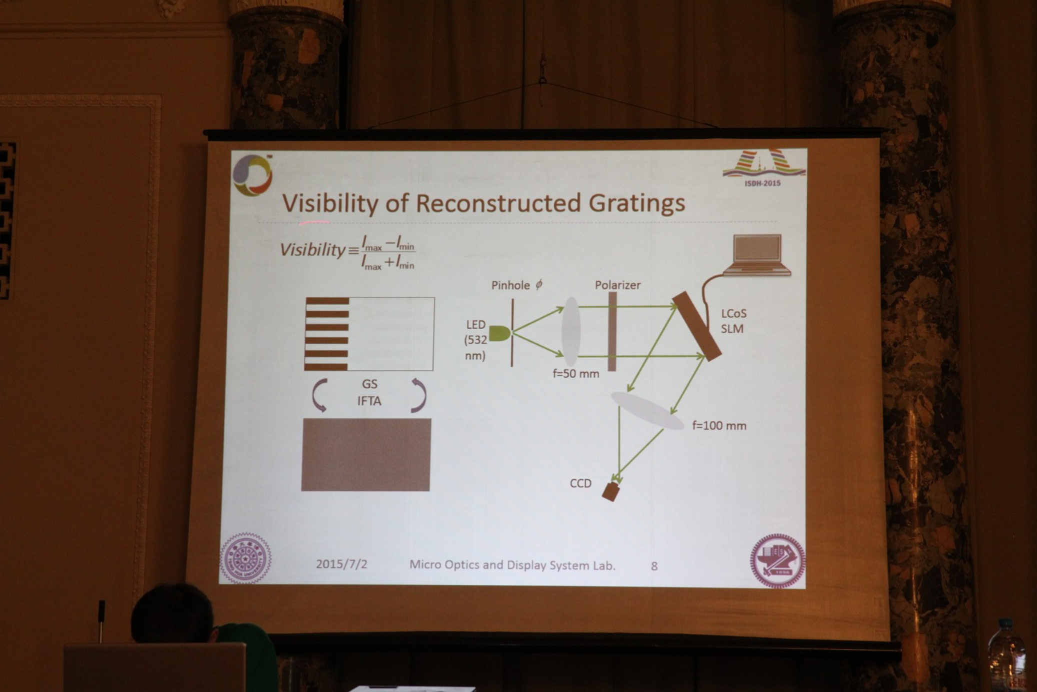
T. Ito et al., *Opt. Letters* **27**(16), 1406-1408 (2002).

Off-axis LED reconstruction



LED pinhole size=0.3 mm

L-Y Liao et al., *SID Int. Symp. Dig. Tec.* **44**(1), 905-908 (2013).


ISDH-2015
Visibility of Reconstructed Gratings
$Visibility \equiv \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$
GS
IFTA
Pinhole ϕ
Polarizer
LED
(532
nm)
f=50 mm
LCoS
SLM
f=100 mm
CCD
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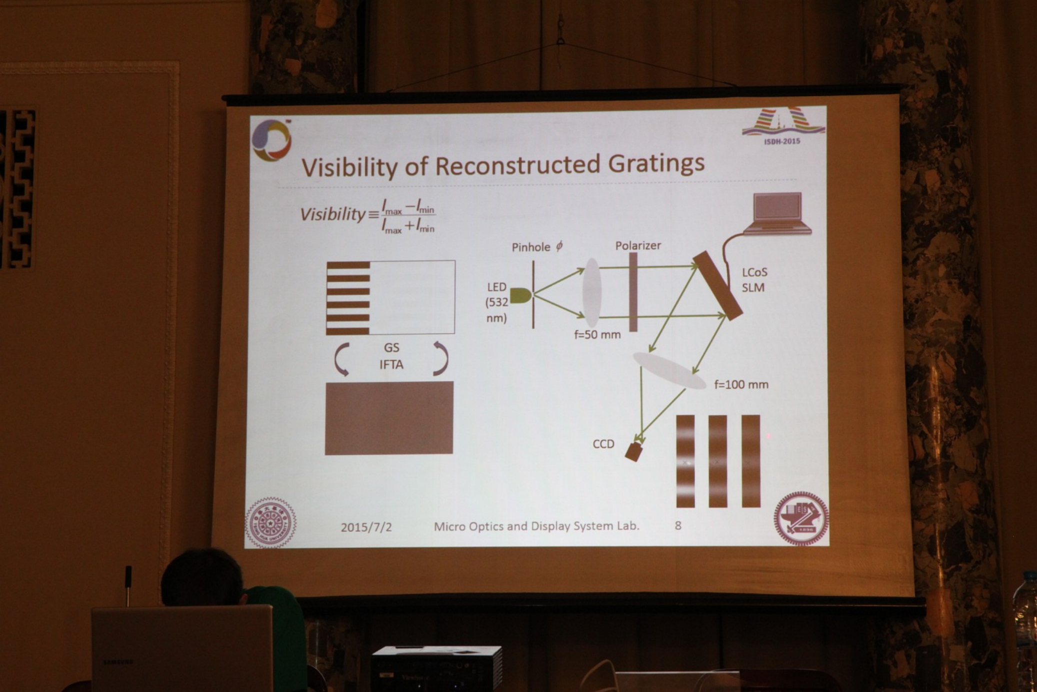
ISDH-2015
Visibility of Reconstructed Gratings
$Visibility \equiv \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$
GS
IFTA
Pinhole ϕ
Polarizer
LED
(532
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f=50 mm
LCoS
SLM
f=100 mm
CCD
2015/7/2
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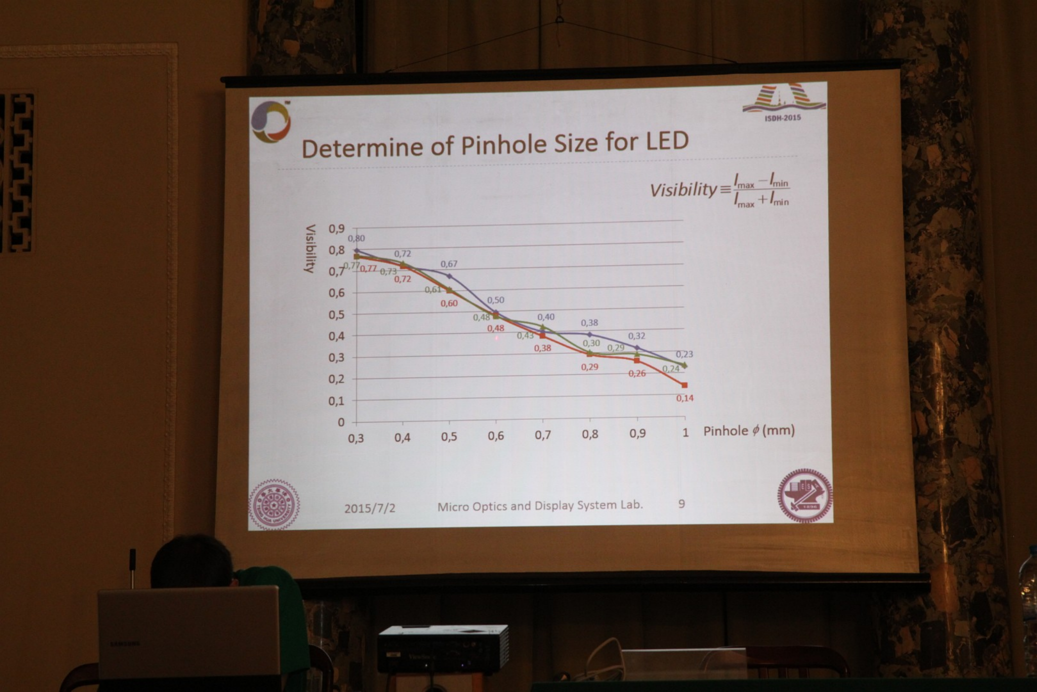
ISDH-2015
Determine of Pinhole Size for LED
$Visibility \equiv \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$
Visibility
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
0,3
0,4
0,5
0,6
0,7
0,8
0,9
1
Pinhole ϕ (mm)
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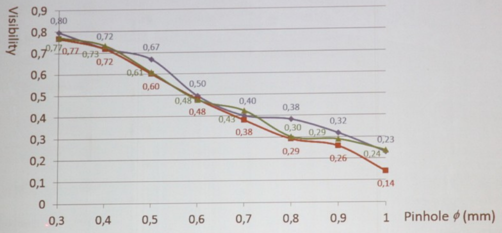
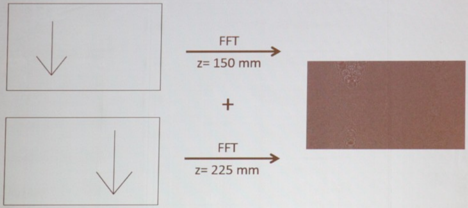
Determine of Pinhole Size for LED

$$Visibility \equiv \frac{I_{max} - I_{min}}{I_{max} + I_{min}}$$



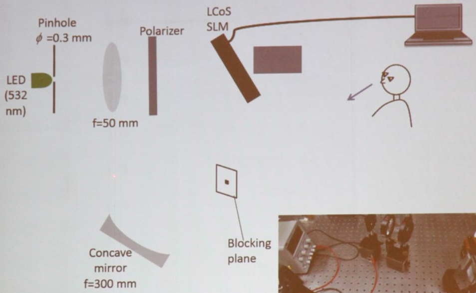
Concept of CGHs Pattern Generation

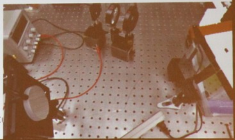
- The layer-based method to create 3D image
- Two picture with different depths in one CGH pattern

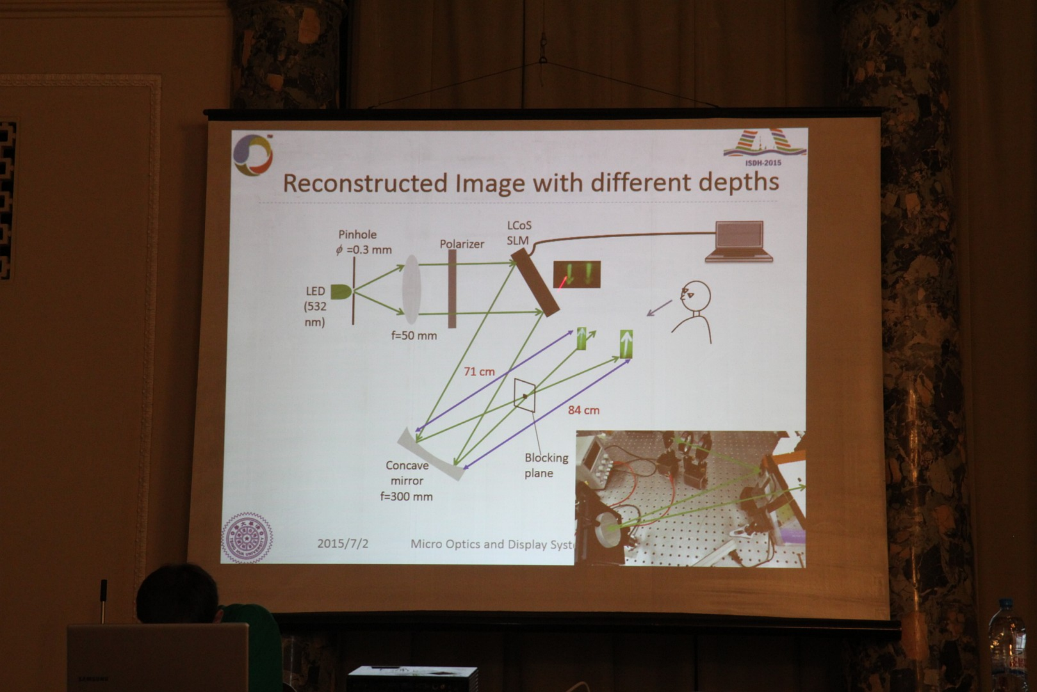


ISDH-2015

Reconstructed Image with different depths






ISDH-2015
Reconstructed Image with different depths
Pinhole
ϕ =0.3 mm
Polarizer
LCoS
SLM
LED
(532
nm)
f=50 mm
71 cm
84 cm
Concave
mirror
f=300 mm
Blocking
plane
2015/7/2
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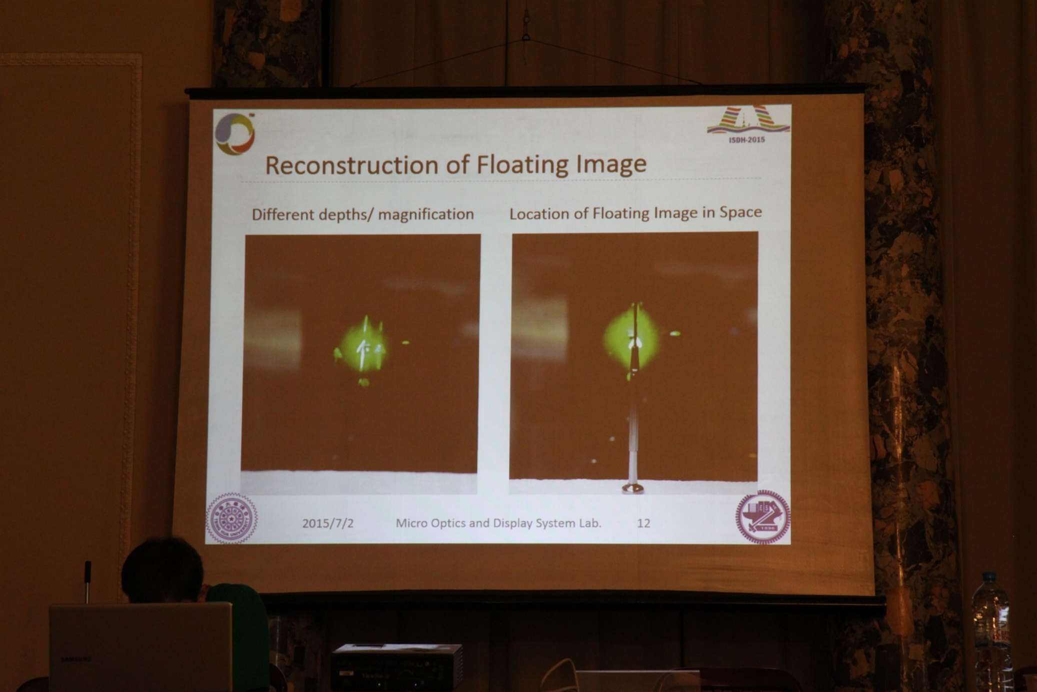
ISDH-2015
Reconstruction of Floating Image
Different depths/ magnification
Location of Floating Image in Space
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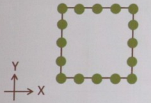
Layer-Based Method to Generate 3D Object

- 2D image with different depths can compose of a 3D image
- By using rotation matrix, we get a rotation 3D image with different coordinates in each point



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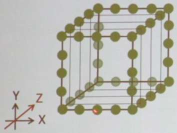

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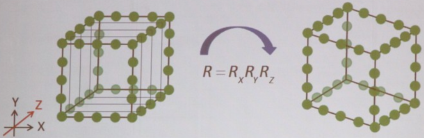
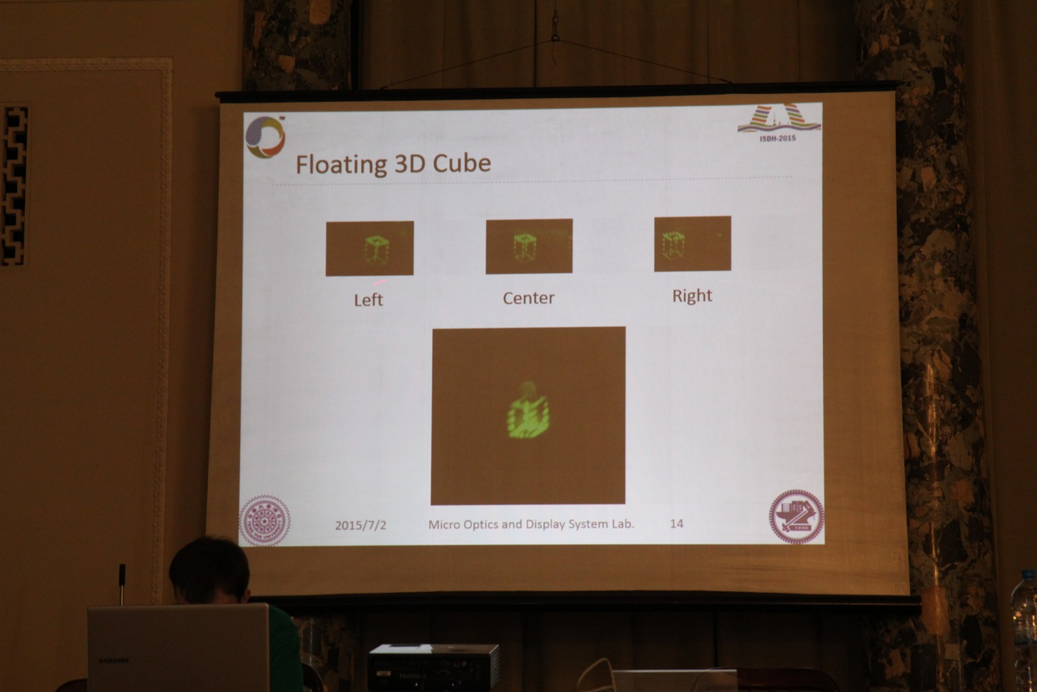


44 points with **different propagating distance(depth: z)** and **layer(2D: xy) information**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Floating 3D Cube
Left
Center
Right
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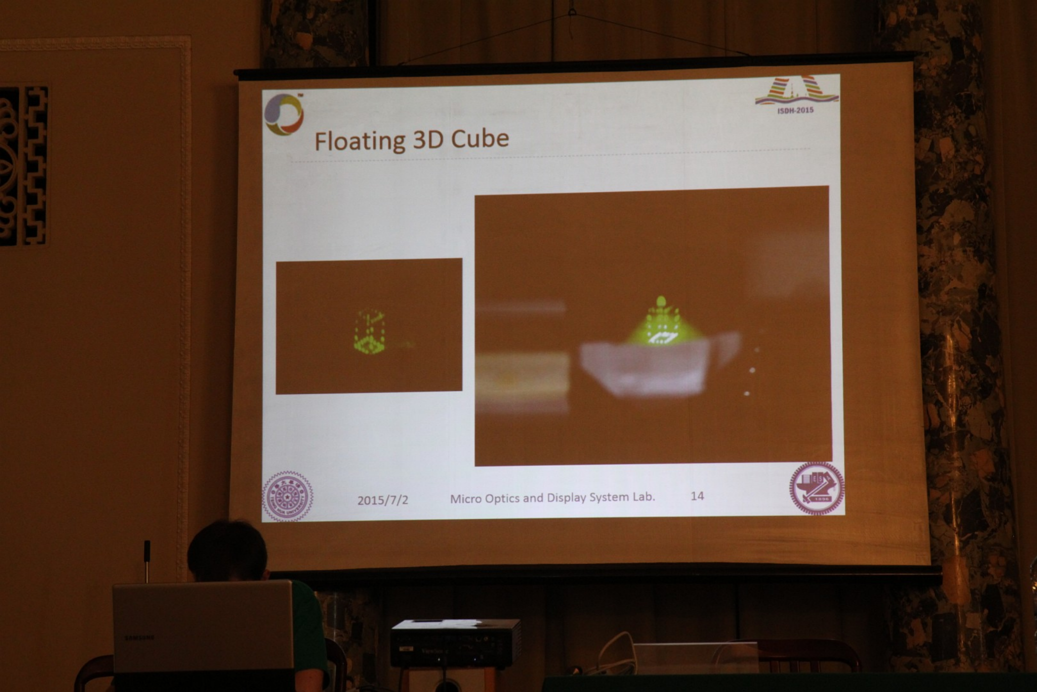
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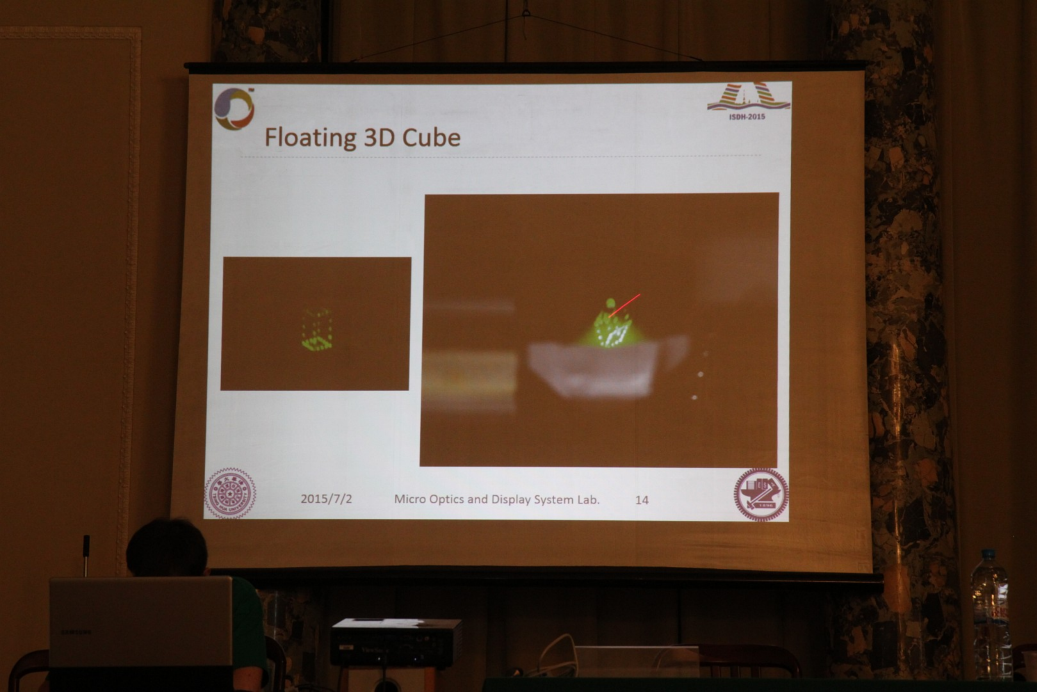
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Floating 3D Cube
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Conclusions

- We propose a holographic display architecture by using extra imaging optics associated with phase LCoS SLM, and uses green LED source for reconstruction.
- Under certain condition, the size of pinhole for a satisfactory image quality can be determined by reconstructed gratings visibility.
- This prototype shows a promising result to display a floating 3D image with the floating distance up to 70 cm.


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Thank You For Your Kind Attention!
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