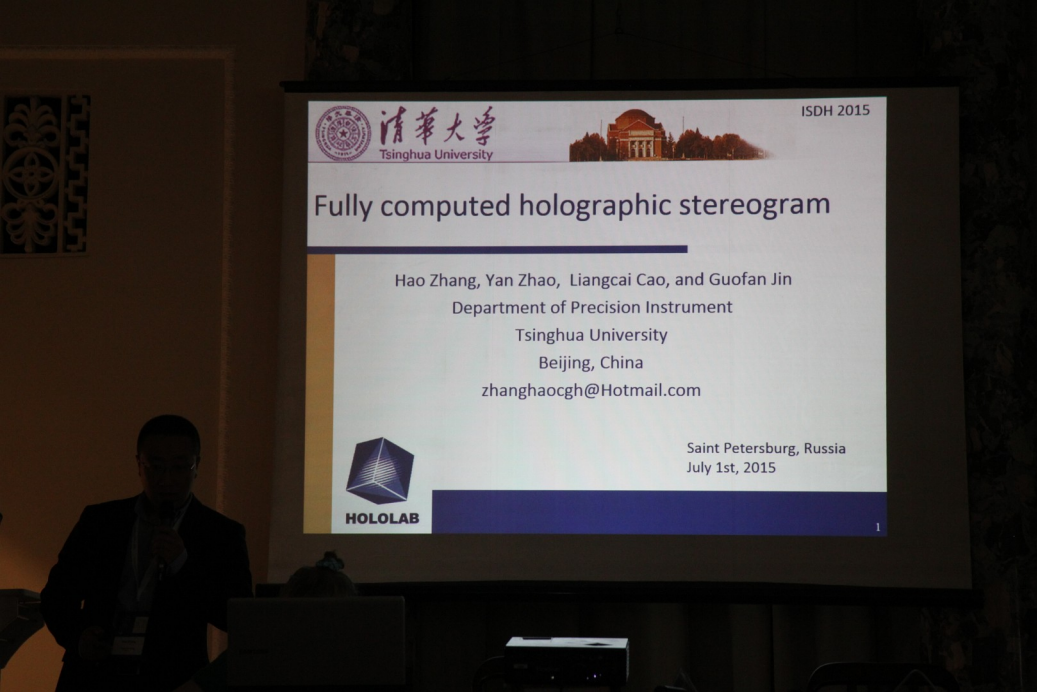
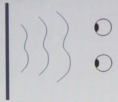
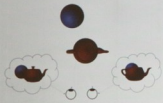

清華大學
Tsinghua University
ISDH 2015
Fully computed holographic stereogram
Hao Zhang, Yan Zhao, Liangcai Cao, and Guofan Jin
Department of Precision Instrument
Tsinghua University
Beijing, China
zhanghaocgh@Hotmail.com
Saint Petersburg, Russia
July 1st, 2015
HOLOLAB
1

Holographic 3D display

- Reconstruction of whole optical wavefront



- Can provide all the depth cues



binocular cues

By Nathaniel Domek

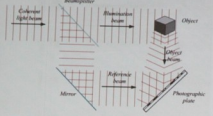
motion parallax & occlusion

accommodation

...

Computer-generated holograms

- Without using interference of coherent light



- Can display both real and virtual scenes

Mathematical representation → Algorithm → Hologram

Can CGHs be more photorealistic?

By Henrik Wann Jensen

Mathematical representation → Render → Image

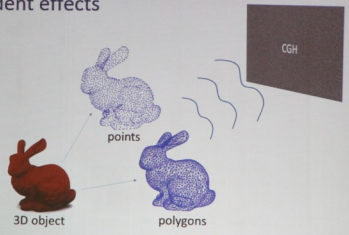
- Lighting
- Geometry
- Texture
- Shadow
- Reflection

Wavefront

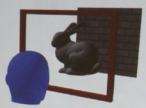
Computer graphics + CGH algorithm

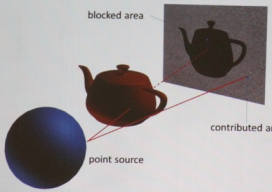
Physically based algorithms

- Modeling optical wave transmission
- Discretizations of 3D scene (points and facets)
- Difficult to express occlusion and other view dependent effects



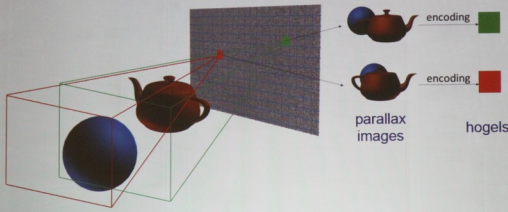
Motion parallax and occlusion effect

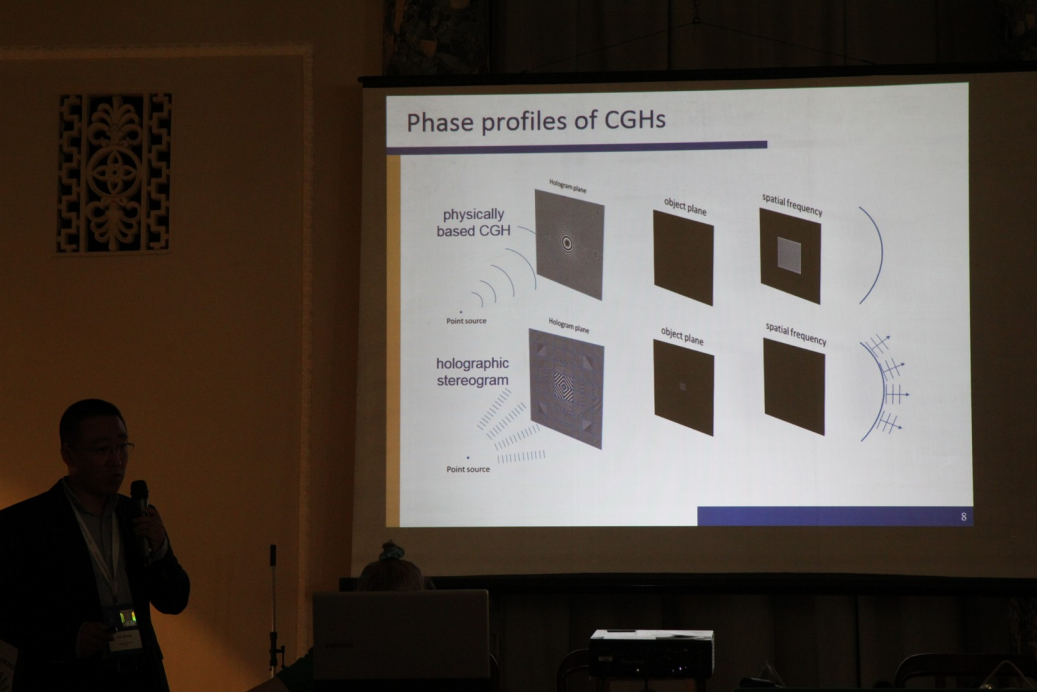




Holographic stereogram

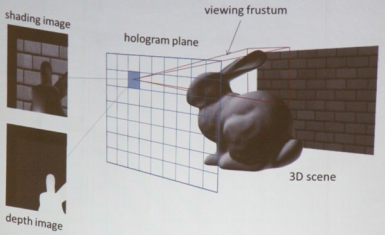
- Computer graphics implemented
- Lack of depth information




Phase profiles of CGHs
physically based CGH
Hologram plane
object plane
spatial frequency
Point source
holographic stereogram
Hologram plane
object plane
spatial frequency
Point source
8

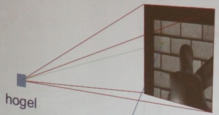
Fully-computed holographic stereogram

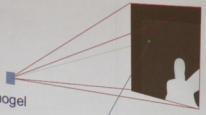
Physically based algorithm + Holographic stereogram based algorithm



Hao Zhang, et al. "Fully computed holographic stereogram based algorithm for computer-generated holograms with accurate depth cues," Opt. Express 23, 3901-3913 (2015)

Geometrical transmission





A amplitude

$(\theta_x, \theta_y, z_p)$

$$z_o = z_p$$
$$x_o = z_o \tan\theta_x$$
$$y_o = z_o \tan\theta_y$$

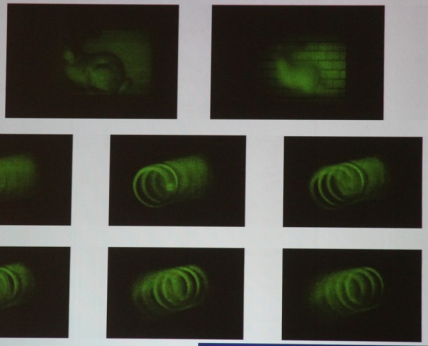
(x_o, y_o, z_o) coordinates

$$\sin\theta_{\max} = f_{\max}\lambda = \frac{1}{2d}\lambda$$

$$h_{hogel}(x,y) = \sum_{j=1}^{N} \frac{A_j}{r_j} \exp\left[i\left(kr_j + \phi_j\right)\right]$$

$$r_j = \sqrt{\left(x - x_j\right)^2 + \left(y - y_j\right)^2 + z_j^{\,2}}$$

Reconstructions using LCOS



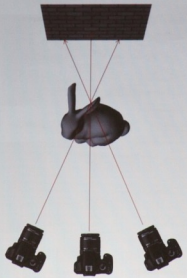
High-resolution CGH

Parameter	Value
Number of pixels	$4 \times 10^8 (20{,}000 \times 20{,}000)$
Pixel pitch	1 micron
Hologram size	20mm×20mm
Modulation type	Binary amplitude
Wavelength	532nm
Viewing angle	30.9°

Optical reconstructions

Focusing on the bunny

Focusing on the wall



Left

Center

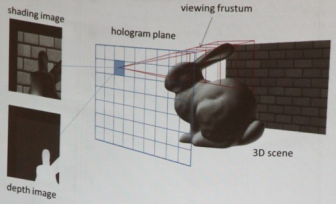
Right

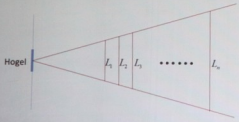
Acceleration

2688 CUDA Cores

CGH(1024x1024)	CPU	GPU	5GPU
1000 points	83.9s	60ms	13ms
5000 points	427.9s	298ms	65ms
10000 points	847.4s	605ms	129ms
50000 points	4203.4s	3002ms	664ms

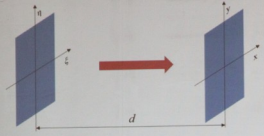
Layered holographic stereogram





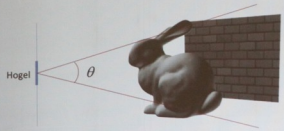
$$H = \sum_{i=1}^{n} Fresnel^{-1}(L_i)$$

Sampling in Fresnel propagation



$$\Delta x = \frac{\lambda d}{N \Delta \xi}$$

$$x \in \left[-\frac{\lambda d}{2\Delta \xi}, \frac{\lambda d}{2\Delta \xi} \right]$$

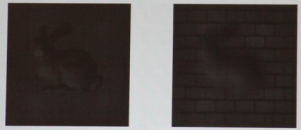


$$\tan\frac{\theta}{2} = \frac{\lambda}{2\Delta \xi}$$

Reconstructions

Point based

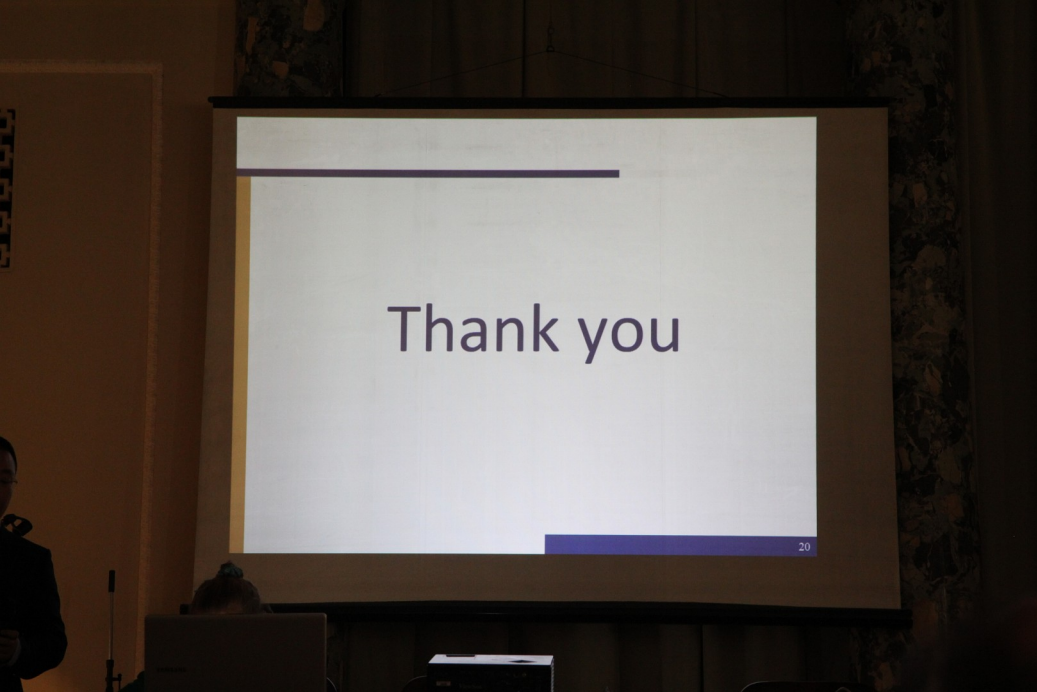
Layer based



Calculation time: 3390s VS 21s (CPU)
2.42s VS ? (GPU)

Conclusion

- Computer graphics rendering can be used in CGH calculation to improve the image fidelity
- More depth information can be reconstructed by integrating physically based algorithm and holographic stereogram
- Use GPU for acceleration


Thank you
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