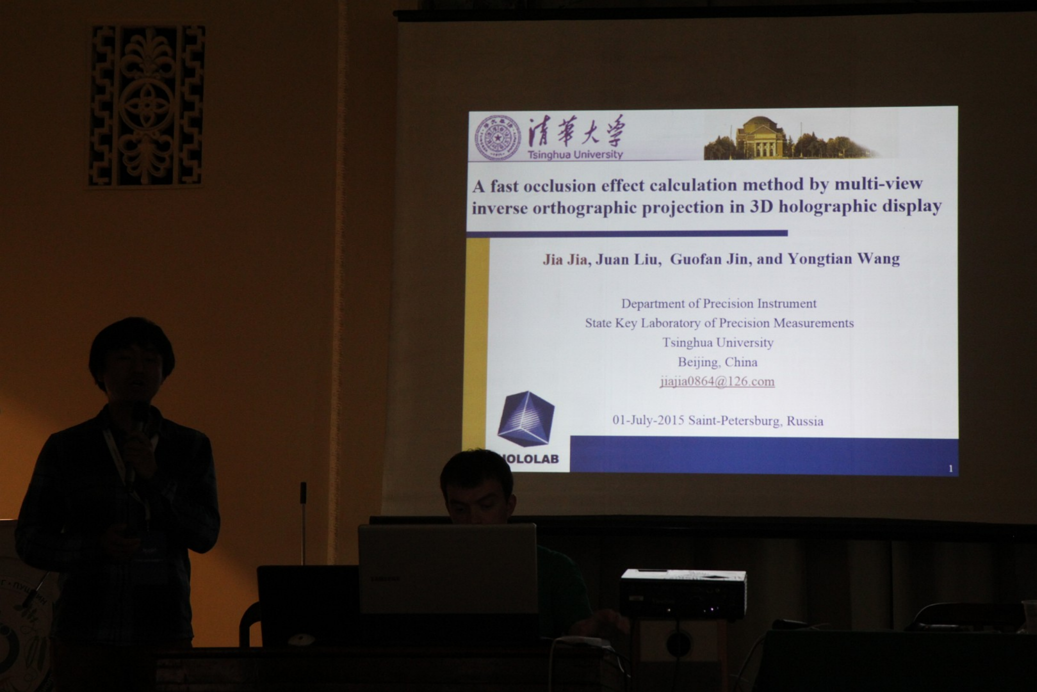
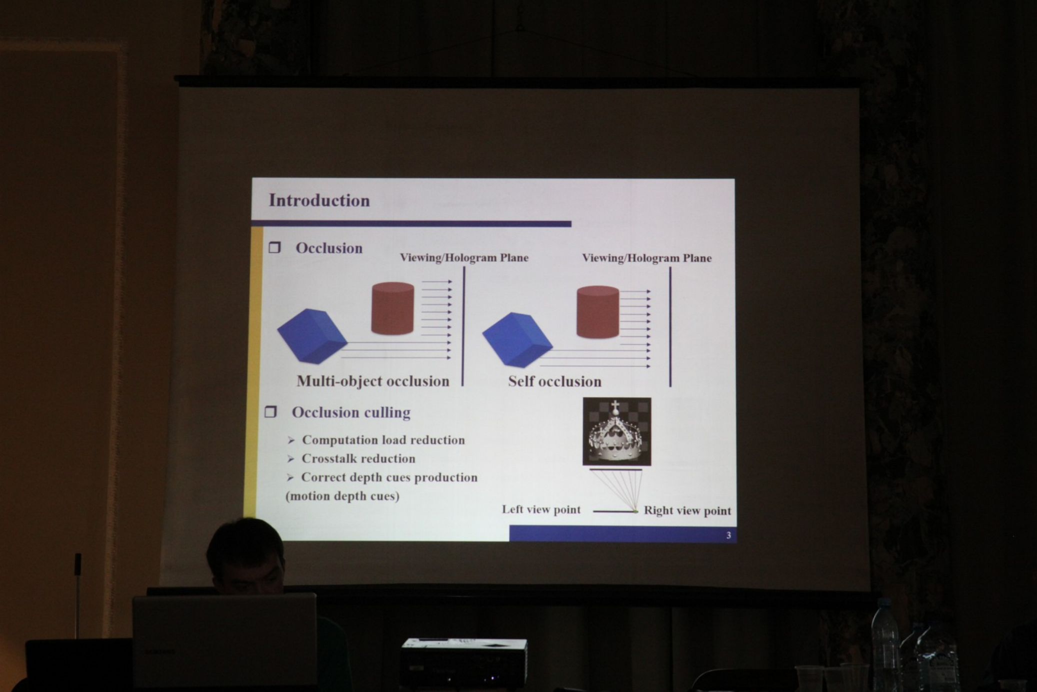

清華大學
Tsinghua University
A fast occlusion effect calculation method by multi-view inverse orthographic projection in 3D holographic display
Jia Jia, Juan Liu, Guofan Jin, and Yongtian Wang
Department of Precision Instrument
State Key Laboratory of Precision Measurements
Tsinghua University
Beijing, China
jiajia0864@126.com
01-July-2015 Saint-Petersburg, Russia
HOLOLAB
1

Outline

- Introduction
- Occlusion culling using inverse orthographic projection
- Design of the angular sampling pitch
- Implement and results
- Conclusion


Introduction
Occlusion
Viewing/Hologram Plane
Viewing/Hologram Plane
Multi-object occlusion
Self occlusion
Occlusion culling
Computation load reduction
Crosstalk reduction
Correct depth cues production
(motion depth cues)
Left view point
Right view point
3

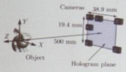
Introduction

❒ Occlusion culling methods

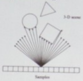
➢ **Based on Ray light**
- Holographic stereogram
- Multi projection

➢ **Based on Extra samplings**
- Mask based
- Ray-tracing

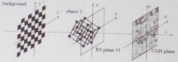
➢ **Others**
- Ray-wave conversion



Multi projection



Ray tracing



Ray-wave conversion

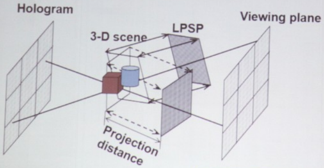
❒ The limitation

➢ Limited to reconstructed deep scene with continue depth
➢ No accommodation cue
➢ Heavy computational load
➢ Poor quality of reconstructed image for deep scene

Rick H.-Y. Chen, Appl. Opt. 48, 4246-4255 (2009)
Koki Wakunami, Opt. Express 21, 21811-21822 (2013)

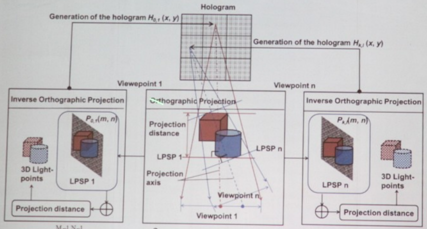
Occlusion culling using inverse orthographic projection

- The principle of our occlusion culling method
  - Step 1: The multiple light point sampling planes are used to remove the hidden surface for each direction of views.
  - Step 2: Inverse orthographic projection is used to obtain the 3D points in real 3D space without any distortion.
  - Step 3: The sub holograms are calculated by the corresponding 3D light points based on wave front.



Occlusion culling using inverse orthographic projection

❐ Occlusion culling of multi objects



$$H_{k,l}(x,y)=\sum_{m,n=0}^{M-1,N-1}A_{k,l}(m,n)\exp[i\frac{2\pi}{\lambda}r_{k,l}(m,n)]\exp(i\phi_{m,n})$$

$$Holo(p,q)=H_{k,l}(p-k\times\frac{s_x}{\Delta u},q-l\times\frac{s_y}{\Delta u})$$

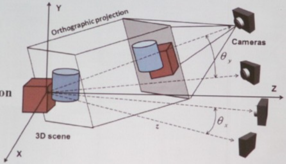
Jia Jia, Appl. Opt. 53, 6287-6293 (2014)

Occlusion culling using inverse orthographic projection

- **Performance of the orthographic projection process by virtual cameras arranged in a spherical configuration.**

Orthographic projection

Perspective projection



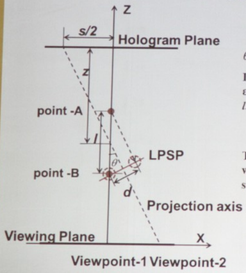
θ_x ,θ_y are angular sampling pitch

Virtual cameras arranged in a spherical configuration

Jia Jia, Appl. Opt. 53, 6287-6293 (2014)

Occlusion culling using inverse orthographic projection

❒ **Designed of angular sampling pitch**



$\theta = arcsin(\frac{2D tan(\varepsilon/2)}{l})$

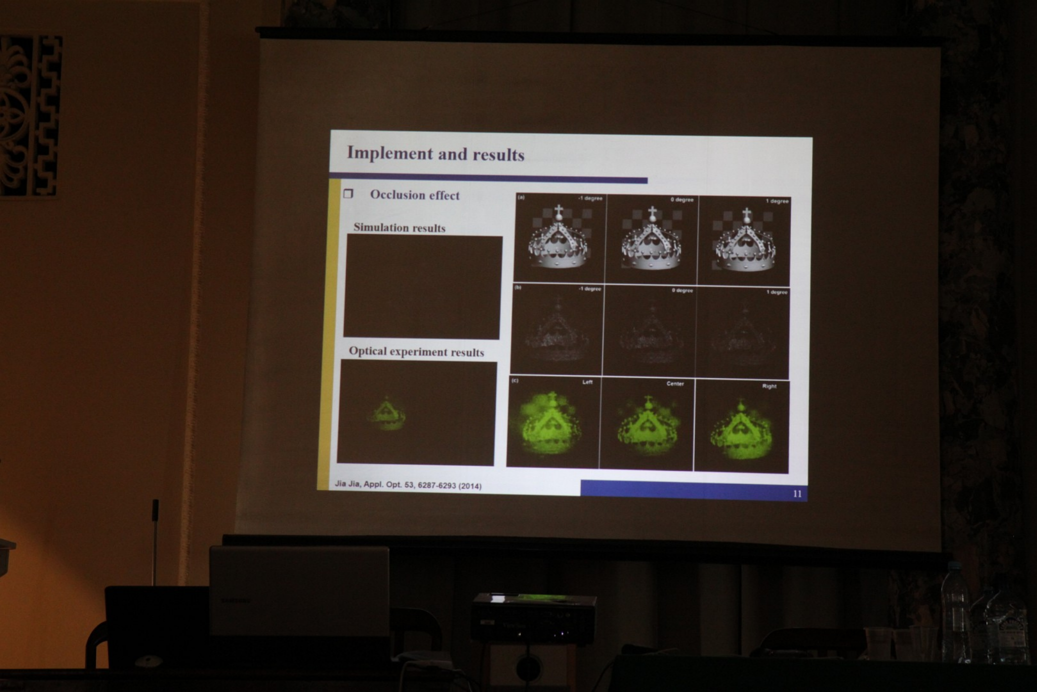
D: the observe distance

ε: the resolution of human eyes

l: the distance between two object points

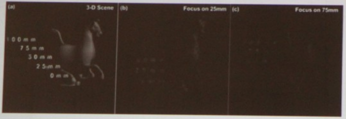
The angular sampling pitch will be large when reconstructing 3D objects with smooth surfaces or shallow depths.

Jia Jia, Appl. Opt. 53, 6287-6293 (2014)


Implement and results
Occlusion effect
Simulation results
Optical experiment results
(a)
-1 degree
0 degree
1 degree
(b)
-1 degree
0 degree
1 degree
(c)
Left
Center
Right
Jia Jia, Appl. Opt. 53, 6287-6293 (2014)
11

Implement and results

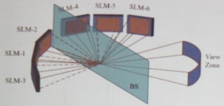
- Reconstruction of a deep 3D scene with continuous depth

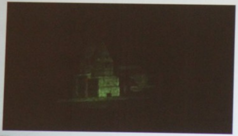


…Jia, Appl. Opt. 53, 6287-6293 (2014)

Implement and results

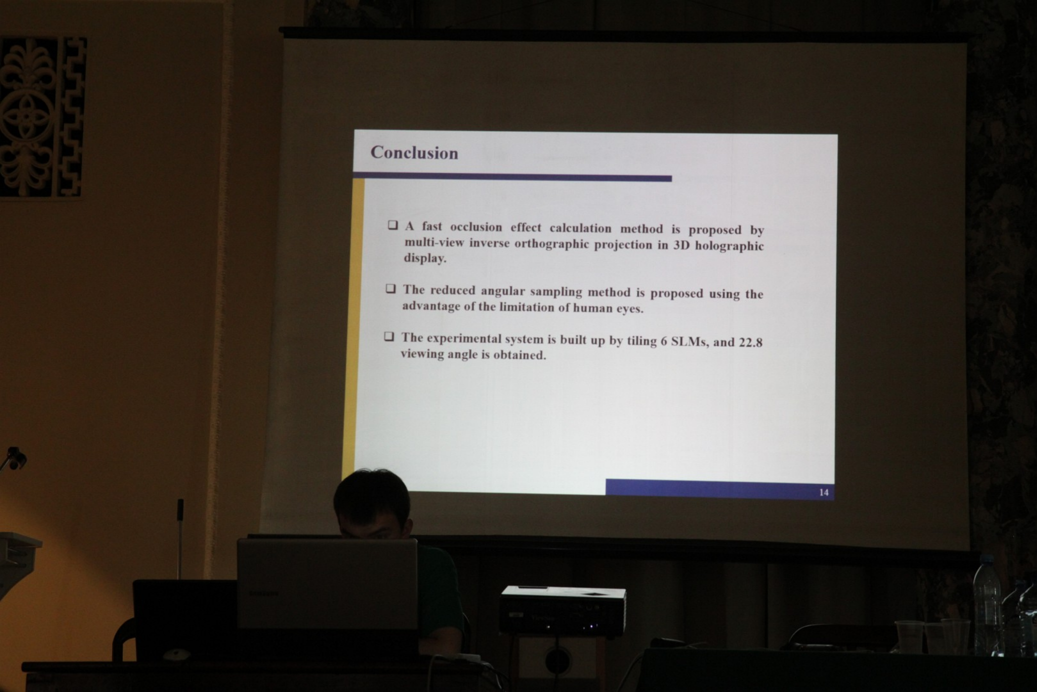
- Experimental system





Spatial light modulators (SLM)
Holoeye Pluto
Resolution: 1920×1080
Pixel pitch: 8um
Screen size: 15.36mm×8.64mm

Viewing zone angle: 22.8 degree


Conclusion
❑ A fast occlusion effect calculation method is proposed by multi-view inverse orthographic projection in 3D holographic display.
❑ The reduced angular sampling method is proposed using the advantage of the limitation of human eyes.
❑ The experimental system is built up by tiling 6 SLMs, and 22.8 viewing angle is obtained.
14


清華大學
Tsinghua University
Thanks for your attention!
Jia Jia
E-mail: jiajia0864@126.com