A fast occlusion effect calculation method by multi-view inverse orthographic projection in 3D holographic display

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Outline

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

- Occlusion
  - Multi-object occlusion
  - Self occlusion

- Occlusion culling
  - Computation load reduction
  - Crosstalk reduction
  - Correct depth cues production
    (motion depth cues)

Viewing/Hologram Plane

Left viewpoint

Right viewpoint
Introduction

- Occlusion culling methods
  - Based on Ray light
    - Holographic stereogram
    - Multi projection
  - Based on Extra samplings
    - Mask based
    - Ray-tracing
  - Others
    - 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

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

\[ H_{ij}(x, y) = \sum_{m=0}^{M} \sum_{n=0}^{N} A_{ij}(m, n) \exp\left(\frac{2\pi}{\lambda} r_{ij}(m, n)\right) \exp(i\phi_{ij}) \]

\[ \text{Holot}(p, q) = H_{ij}(p-k \times \frac{s_x}{\Delta u}, q-l \times \frac{s_y}{\Delta u}) \]

Occlusion culling using inverse orthographic projection

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

Orthographic projection

Perspective projection

Virtual cameras arranged in a spherical configuration

$\theta_1, \theta_2$ are angular sampling pitch.
Occlusion culling using inverse orthographic projection

- Designed of angular sampling pitch

\[ \theta = \arcsin \left( \frac{2D \tan(\varepsilon/2)}{l} \right) \]

- D: the observe distance
- \( \varepsilon \): 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.
Implement and results

- Occlusion effect

Simulation results

Optical experiment results

Implement and results

- Reconstruction of a deep 3D scene with continuous depth

![Diagram showing 3D scene with different focus depths](image-url)
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.
Thanks for your attention!