

Computational Methods for Immersive Perception

Qi Sun

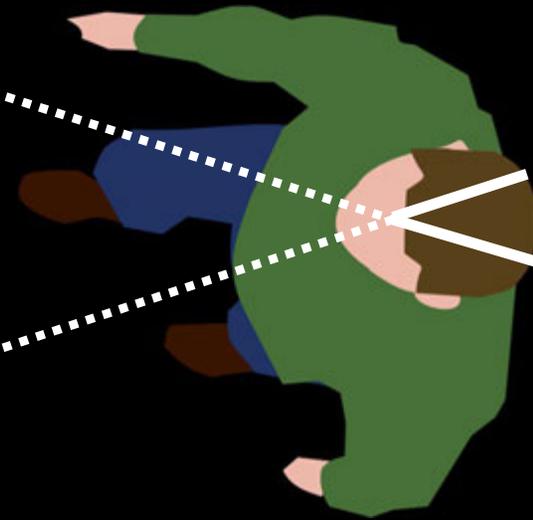
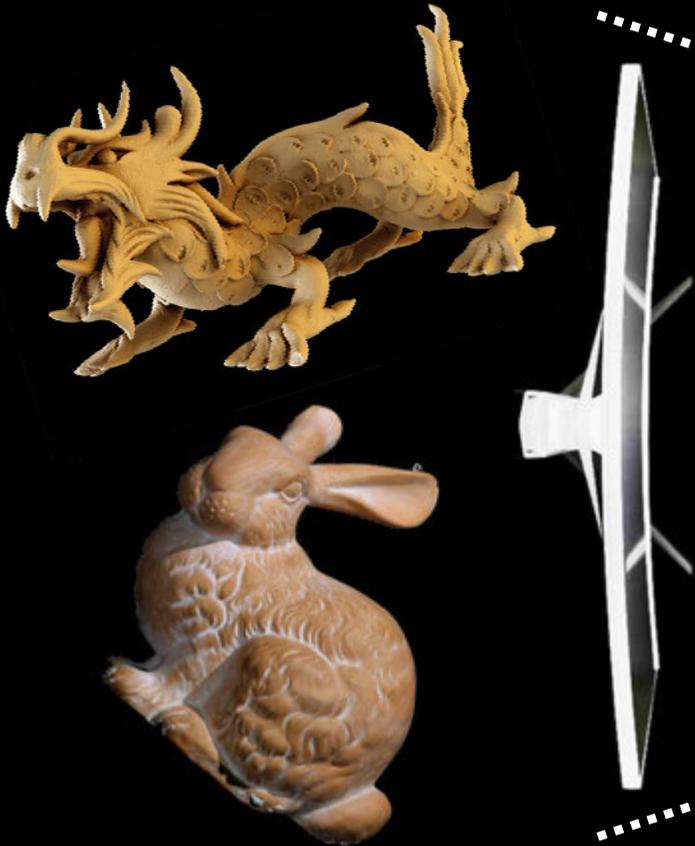
Stony Brook University



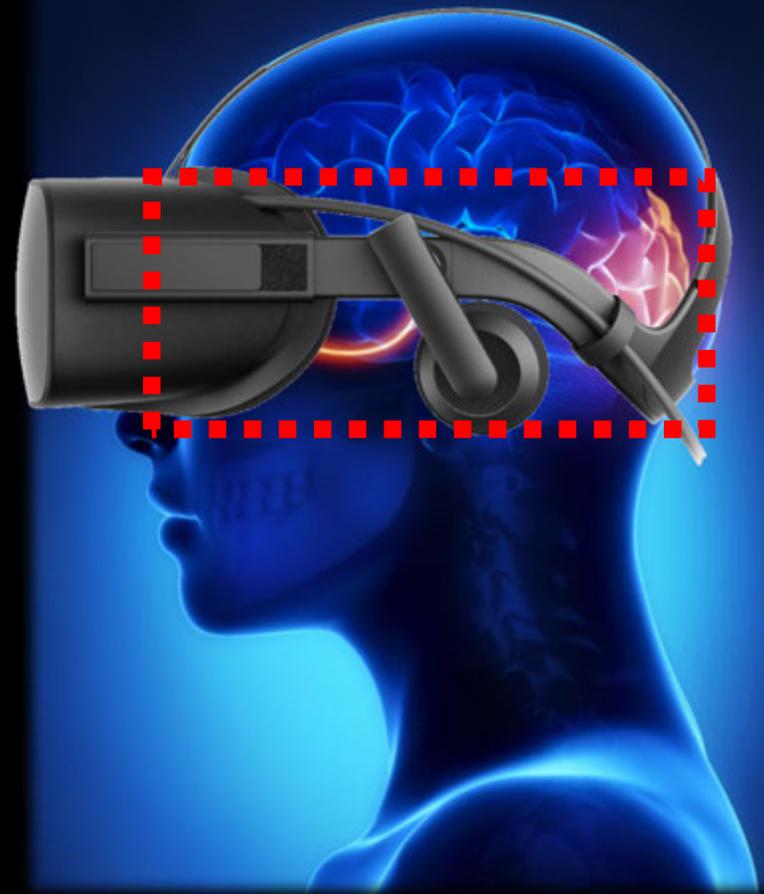


Warehouse/Arts District,
New Orleans, USA

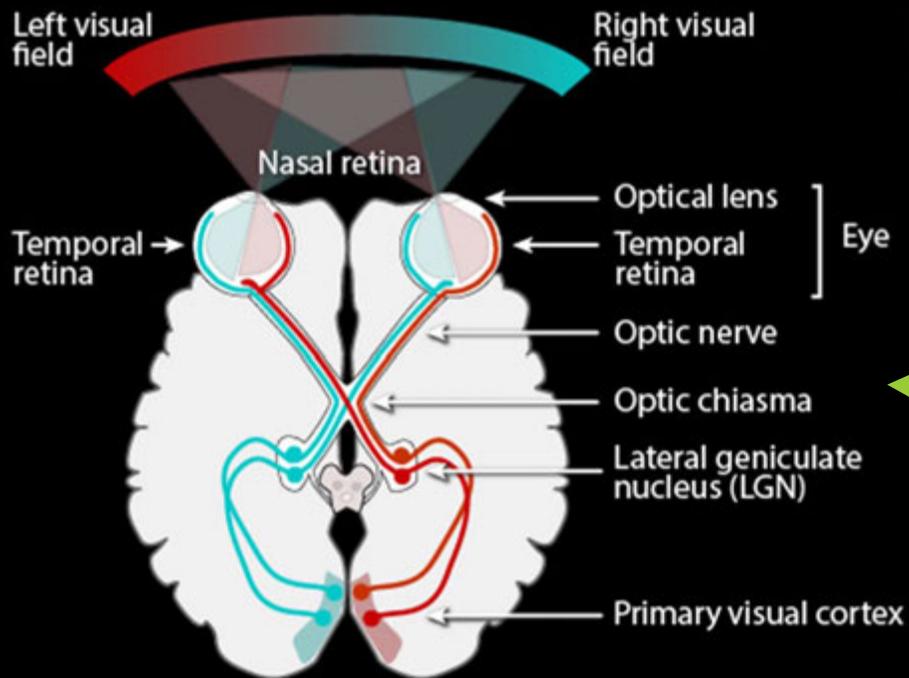
Traditional Visual Media



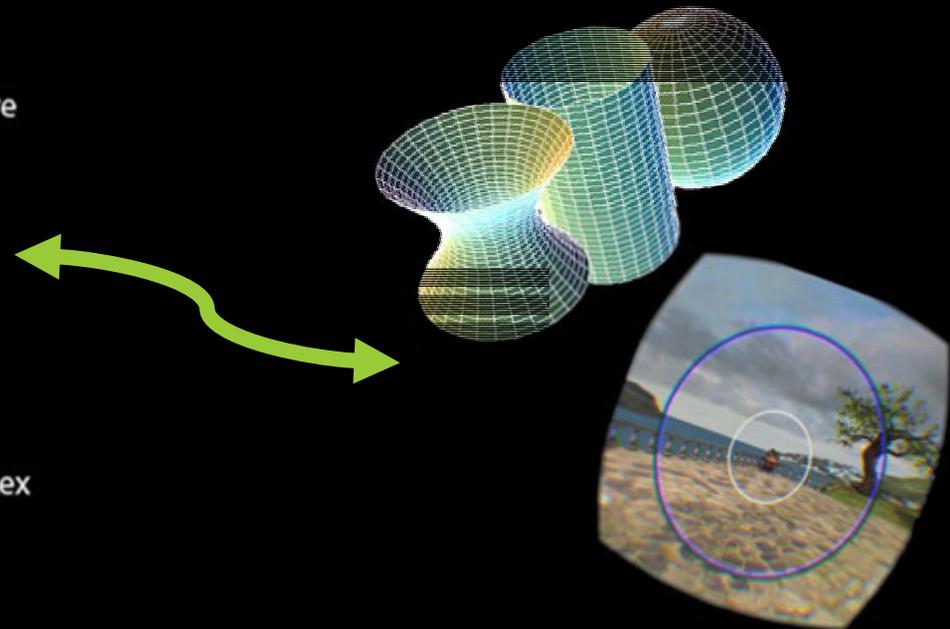
Immersive Visual Media



Perception



Where we are?
What we see?



Where we are?





The 2014 Nobel Prize in Physiology or Medicine



John O'Keefe
Born 1939, USA
University College London

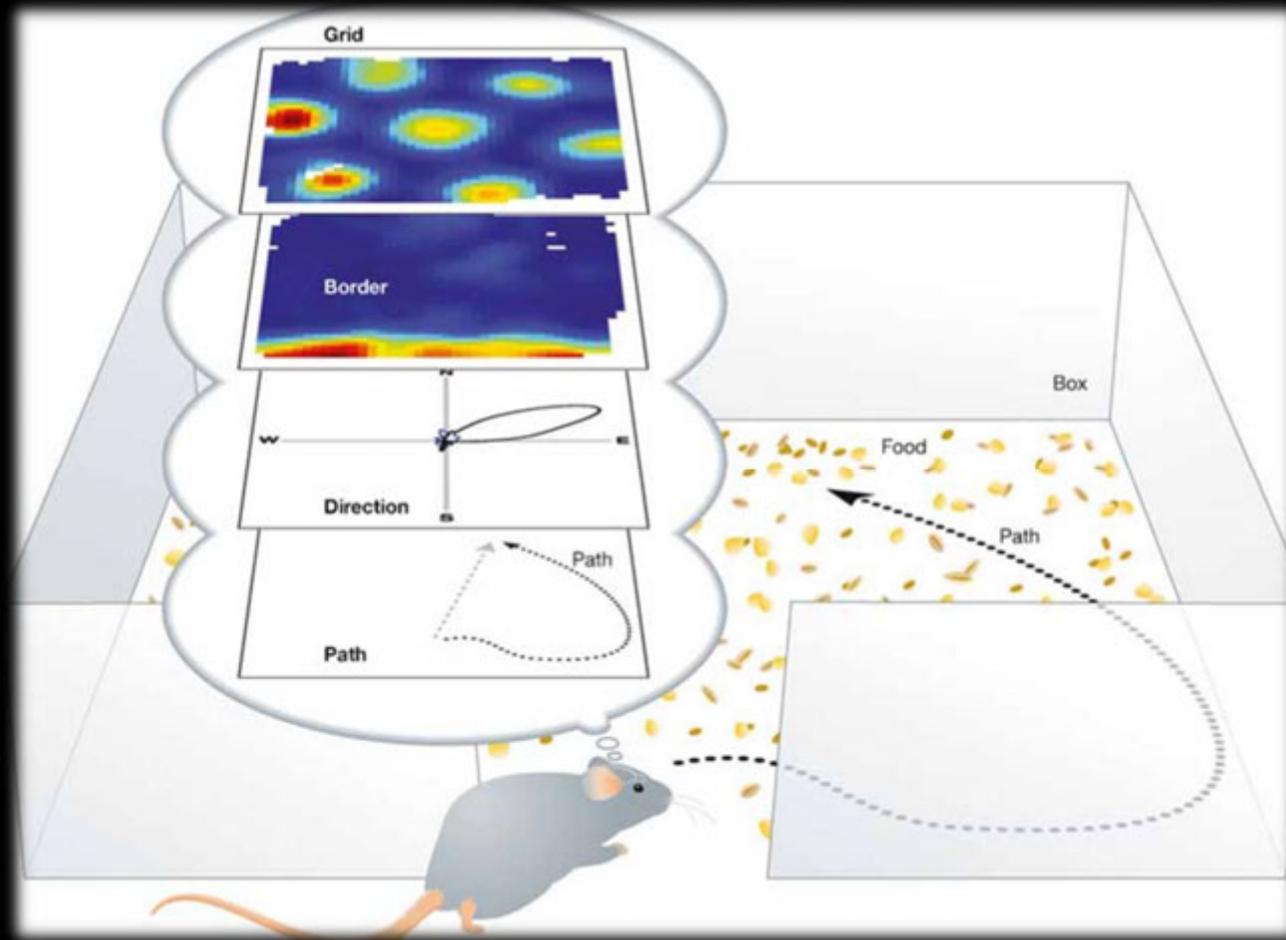


May-Britt Moser
Born 1963, Norway
Norwegian University
of Science and
Technology, Trondheim

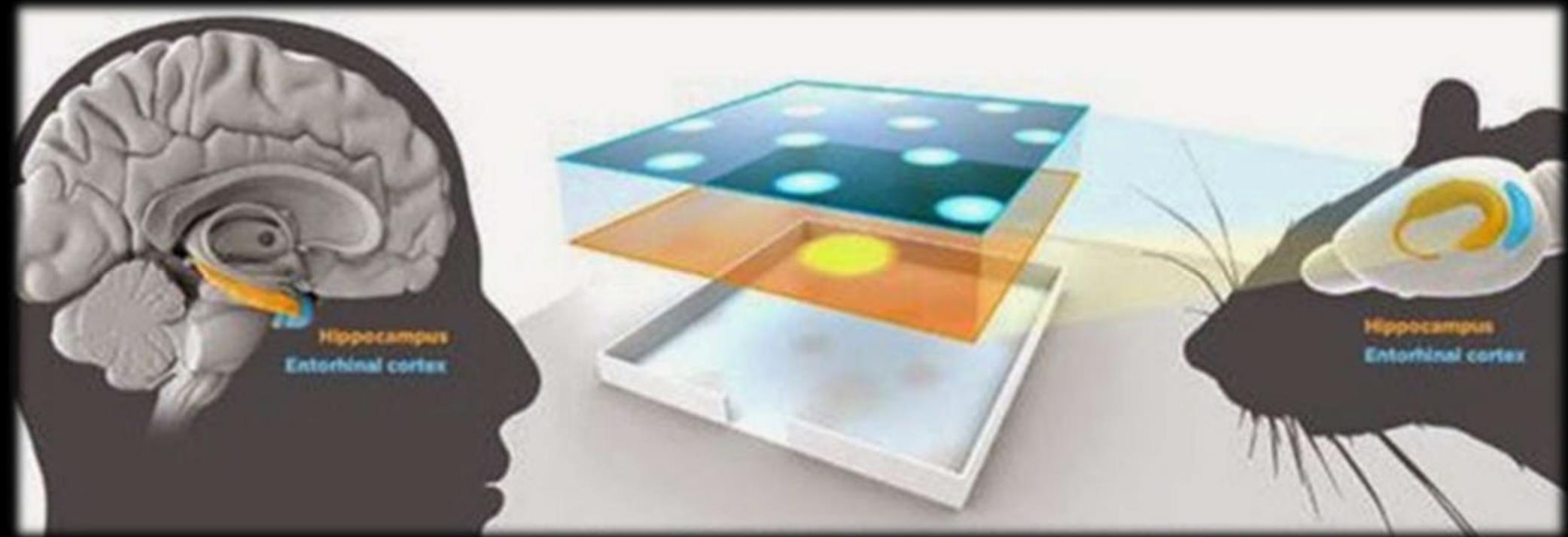


Edvard I. Moser
Born 1962, Norway
Norwegian University
of Science and
Technology, Trondheim

Locomotion System in the Brain



Locomotion System in the Brain



VR Locomotion: Gadgets

☹️ **Un-natural**

😊 **Portable**



VR Locomotion: Walk-in-Place

☹️ Natural?

☹️ Bulky



Free Locomotion

- 😊 Natural
- 😊 Portable
- 😞 Limited space



Constraint: Spatial Mismatching

Virtual World

Real Space



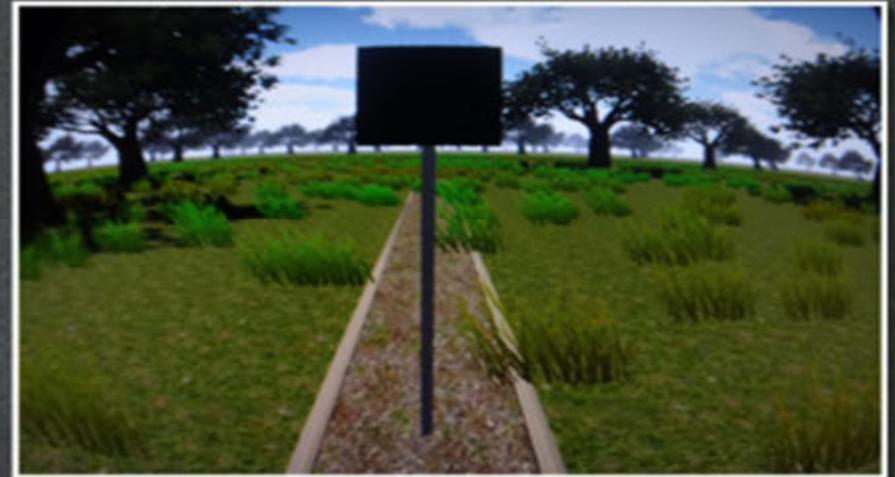
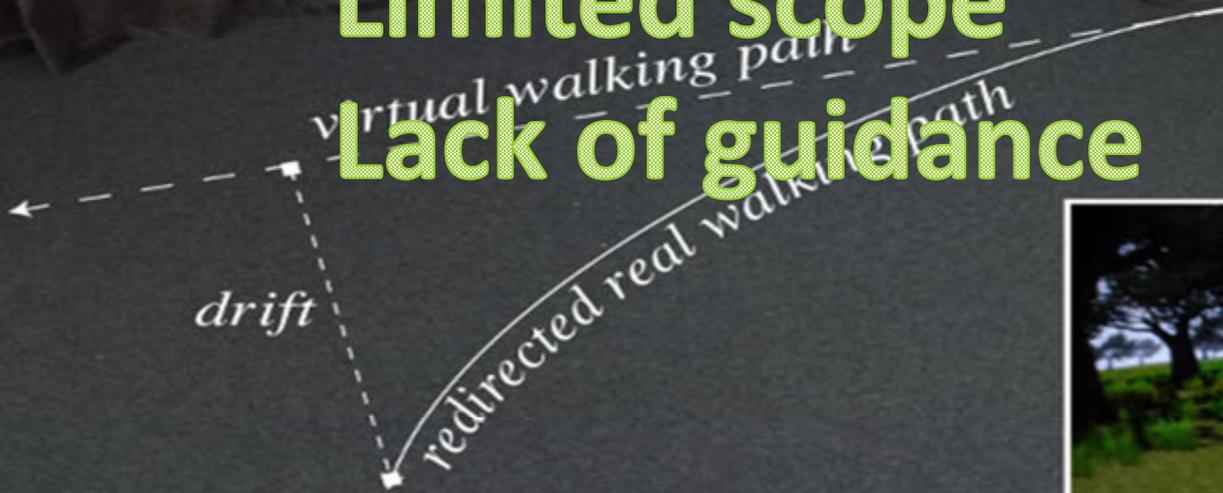
<https://vid.me/gTul>

Redirected Walking

Wiimote

HMD

Limited scope
Lack of guidance

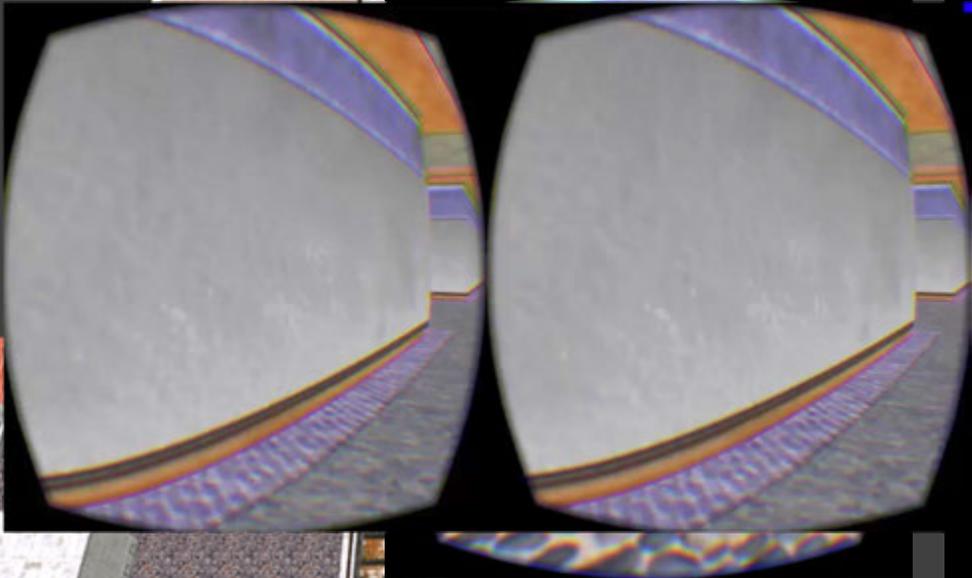


Inception



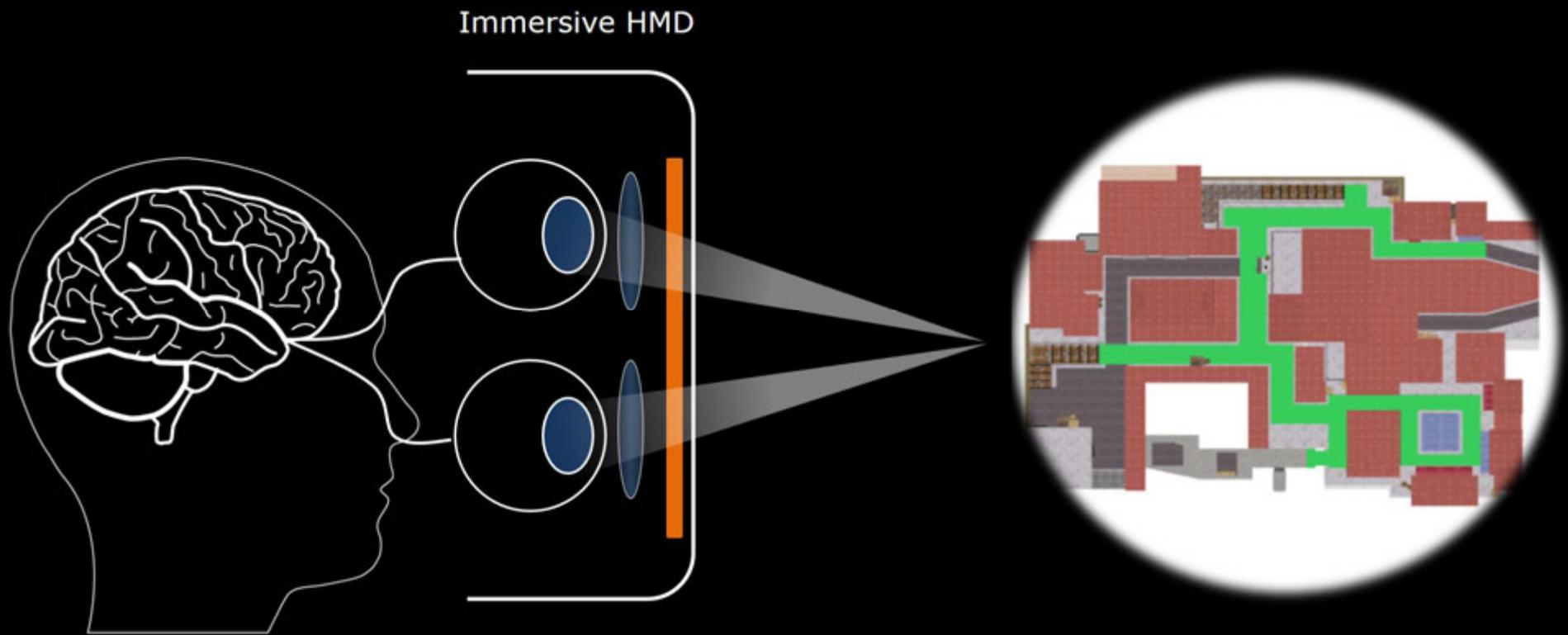
Challenges

- Match **large** virtual and **small** real spaces
- Users move with **comfort** and **safety**
- Accurate locomotion and visual **fidelity**



Mapping Virtual and Physical Reality
Qi Sun, Li-Yi Wei, Arie Kaufman, SIGGRAPH 2016

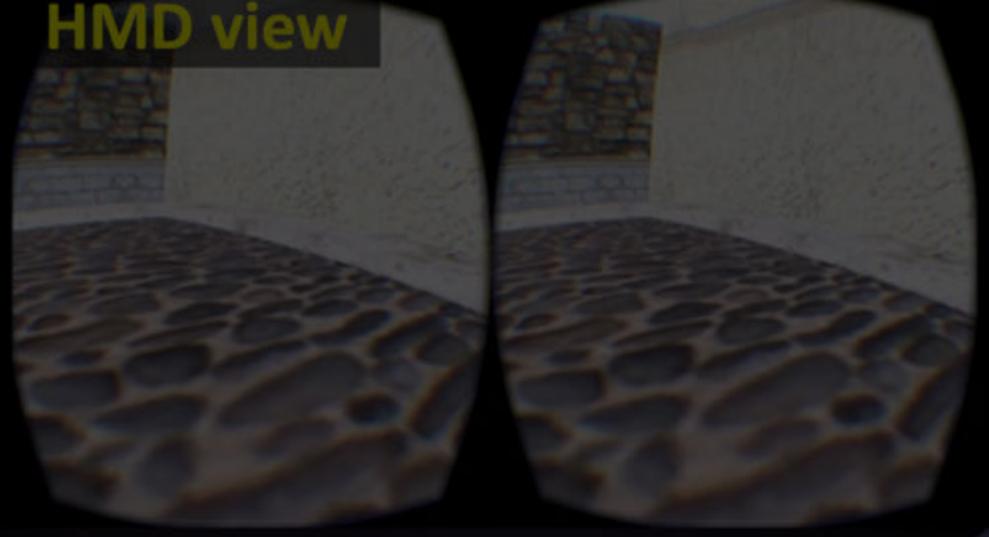
Automatic Content Re-Creation



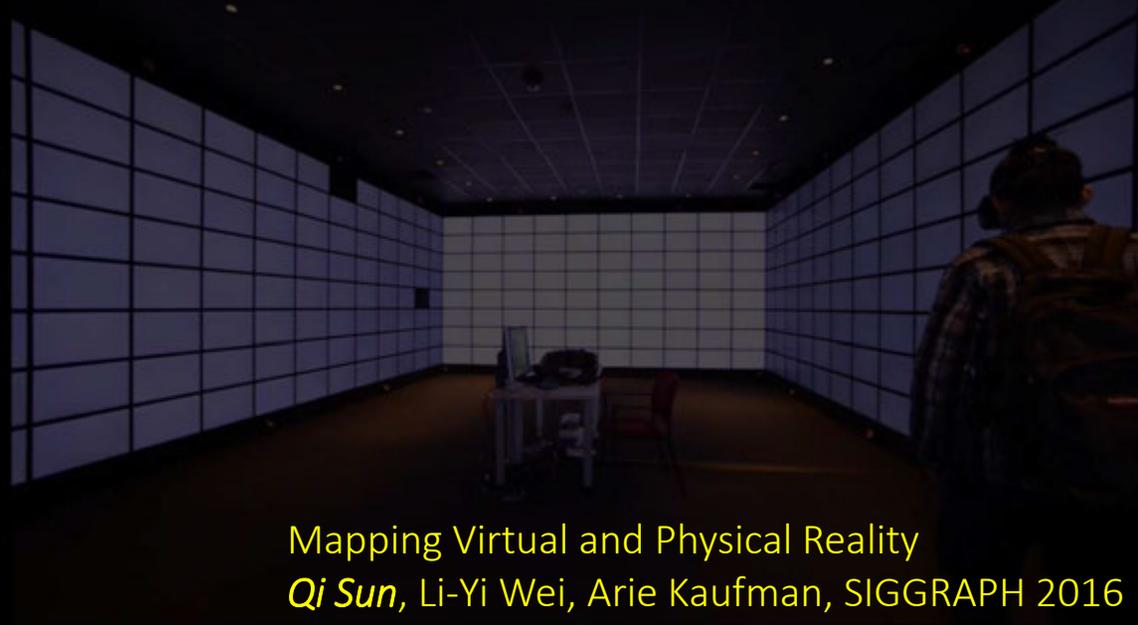
virtual floor plan



HMD view



physical floor plan

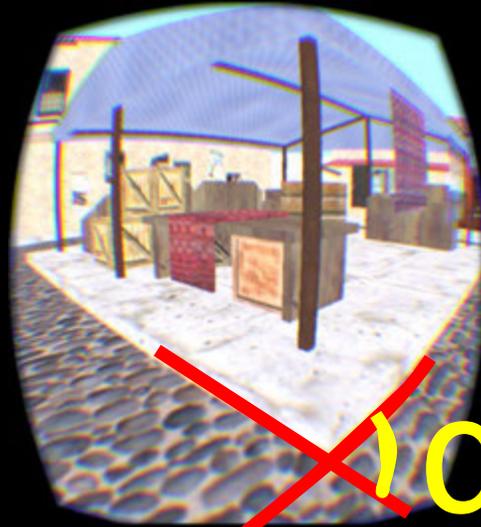


Mapping Virtual and Physical Reality
Qi Sun, Li-Yi Wei, Arie Kaufman, SIGGRAPH 2016

Angle Preserving

min

(|

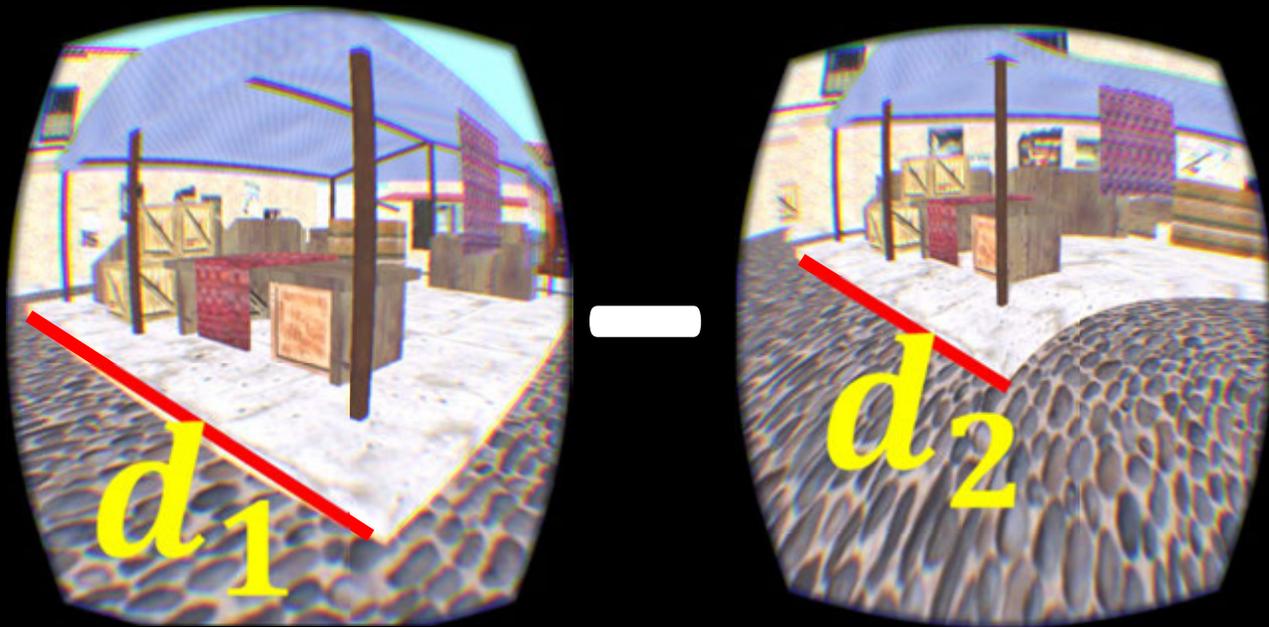


-

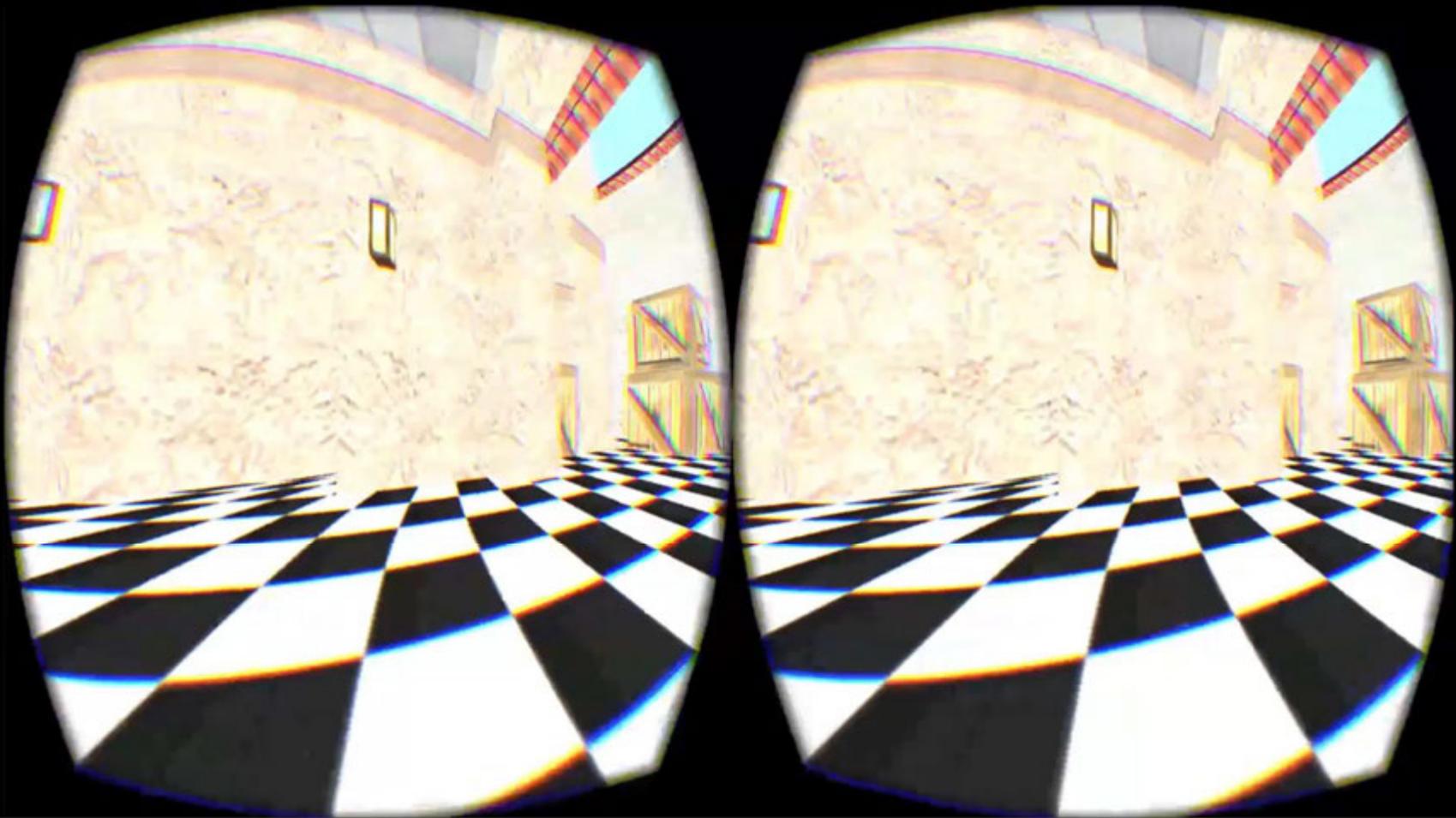


|)

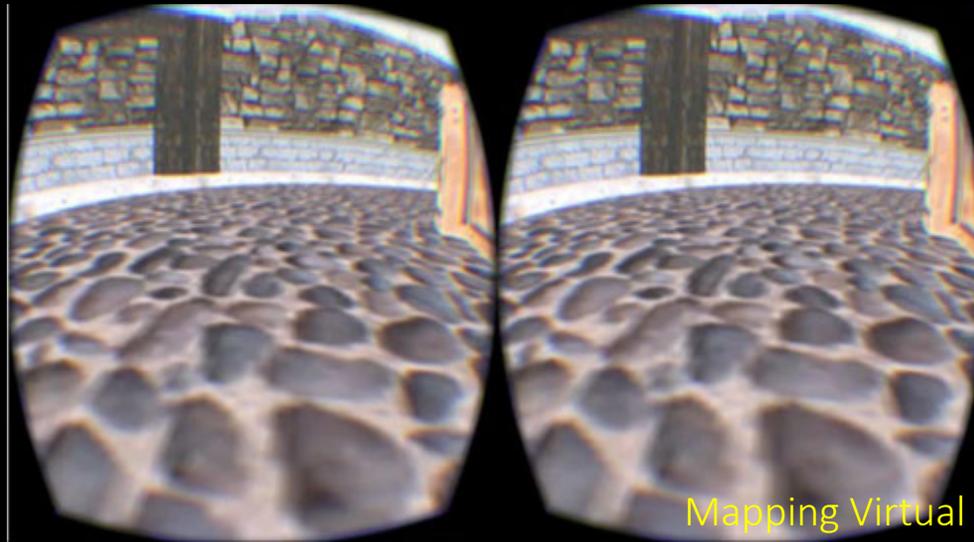
Local Distance Preserving



Geometric Preserving Visualization

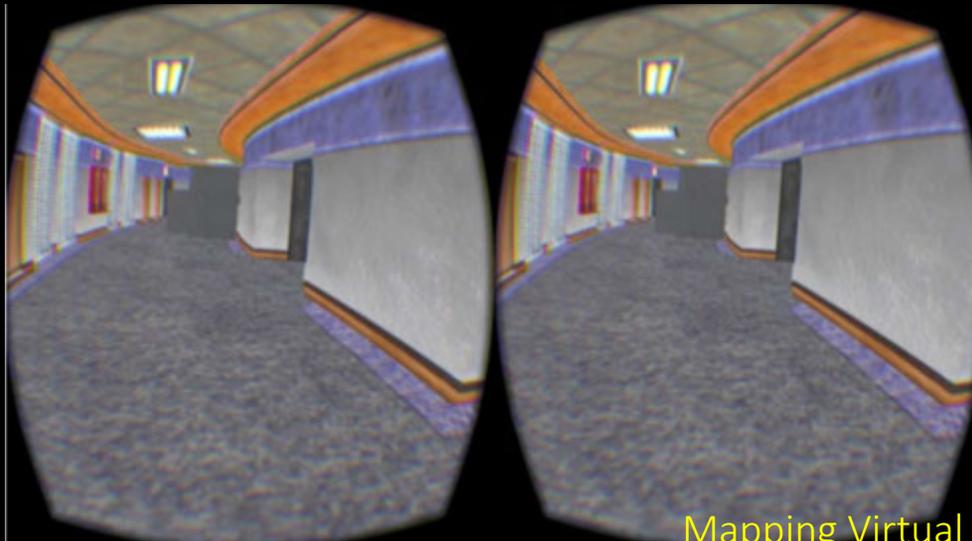
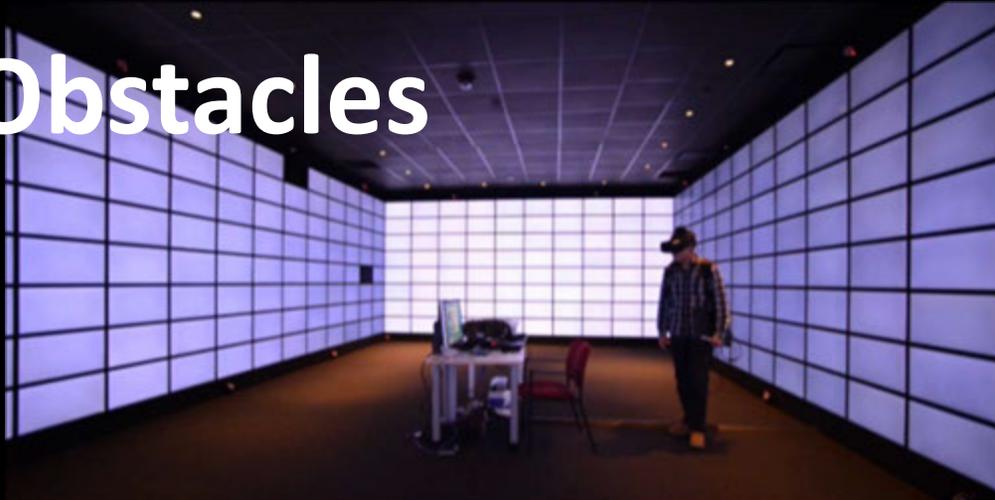


Boundary



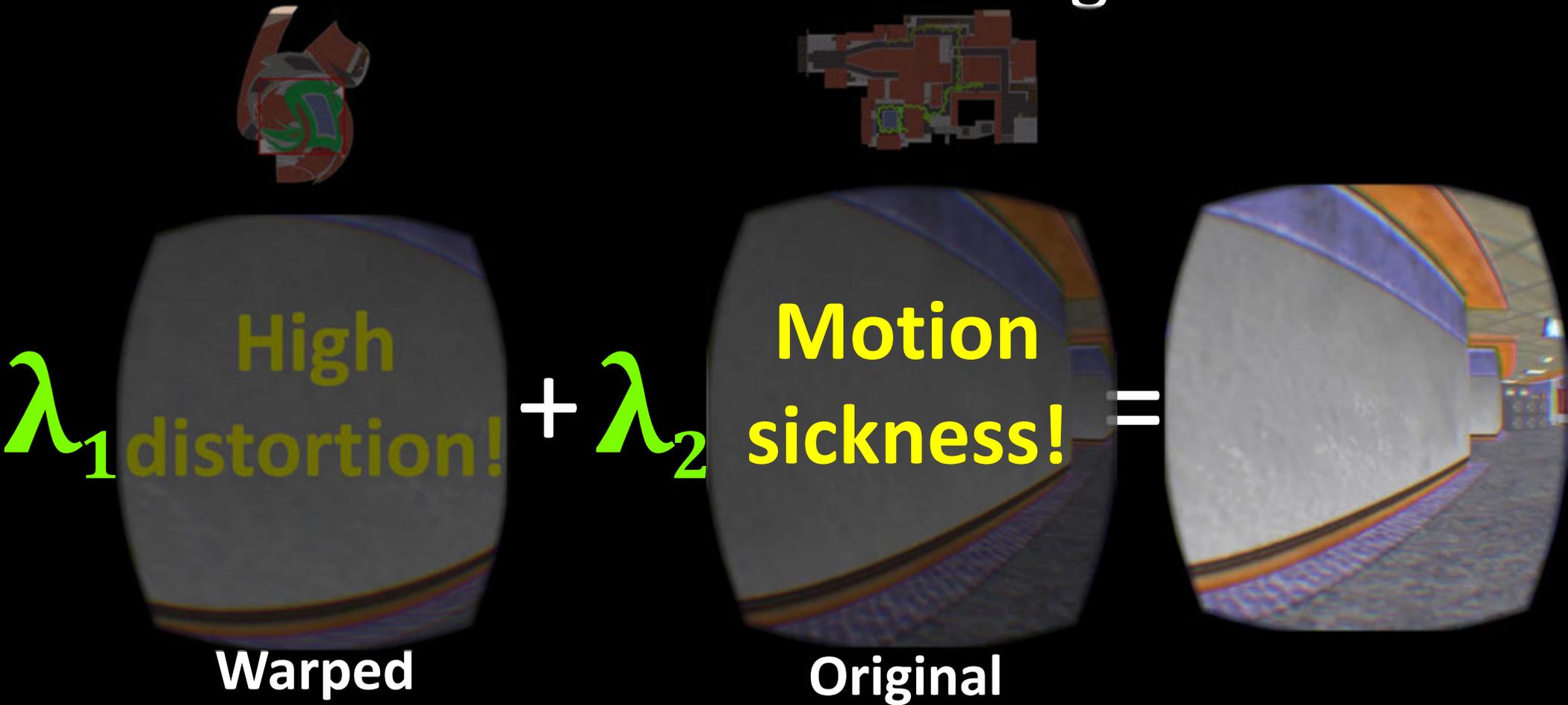
Mapping Virtual and Physical Reality
Qi Sun, Li-Yi Wei, Arie Kaufman, SIGGRAPH 2016

Interior Obstacles

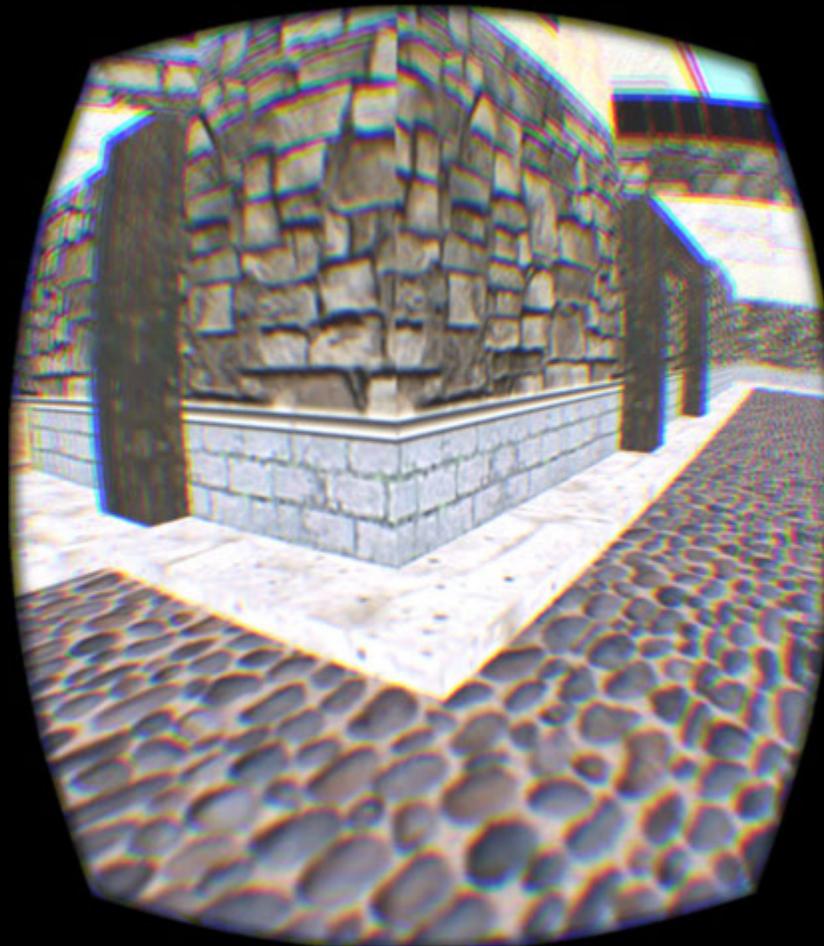


Mapping Virtual and Physical Reality
Qi Sun, Li-Yi Wei, Arie Kaufman, SIGGRAPH 2016

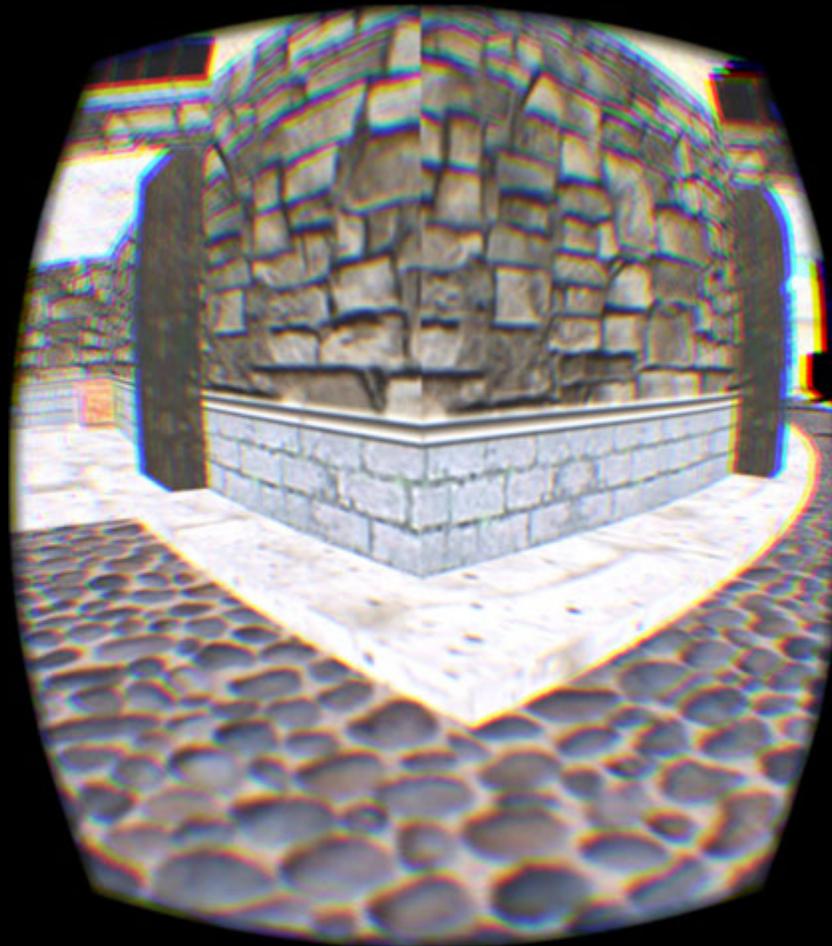
Blended Rendering



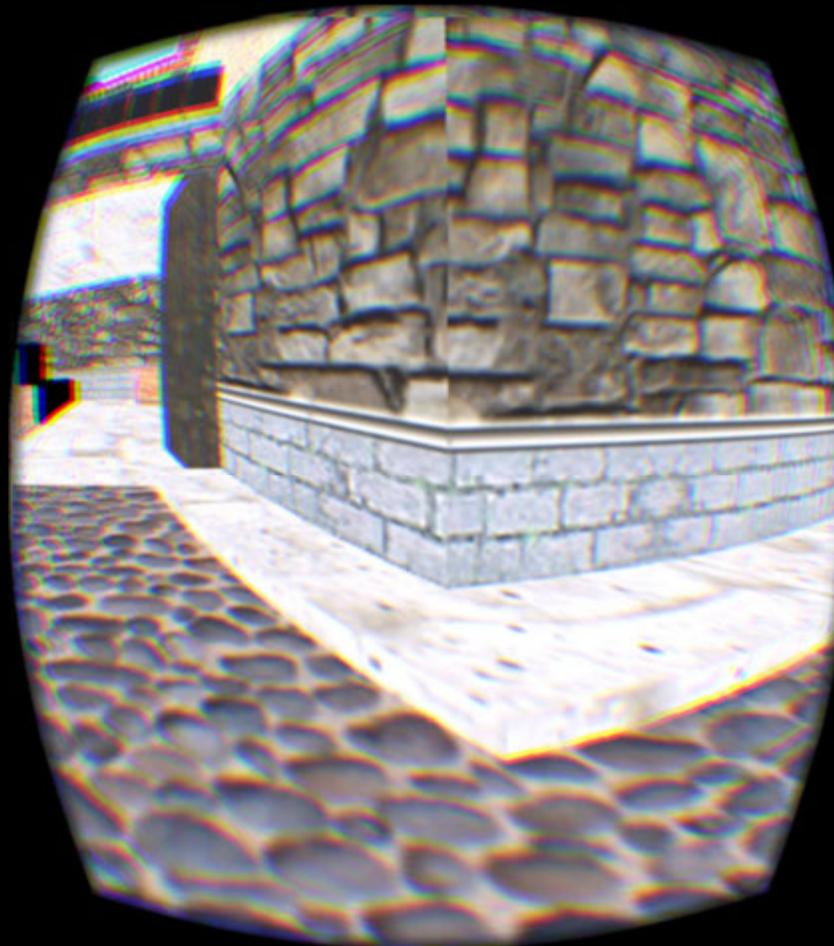
Different Weights



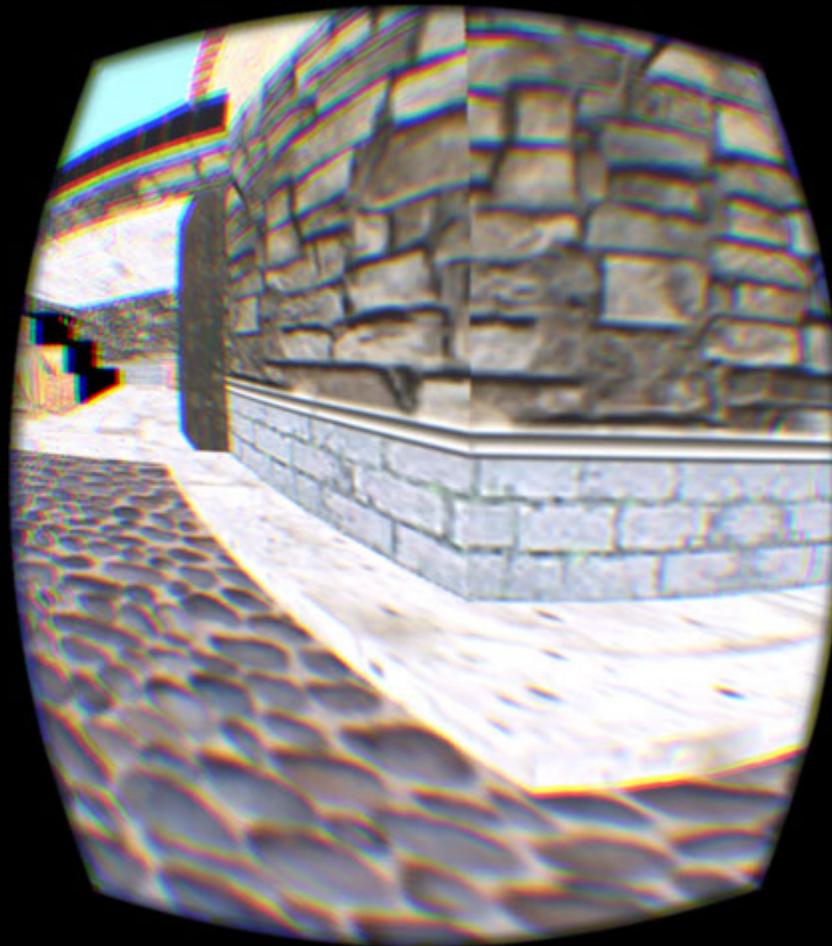
Different Weights



Different Weights



Different Weights



Where we are

- Manipulate visual stimuli for spatial matching
 - Extend image-based modulations to immersive worlds
- Content-aware media re-creation





What we see?

Accommodation

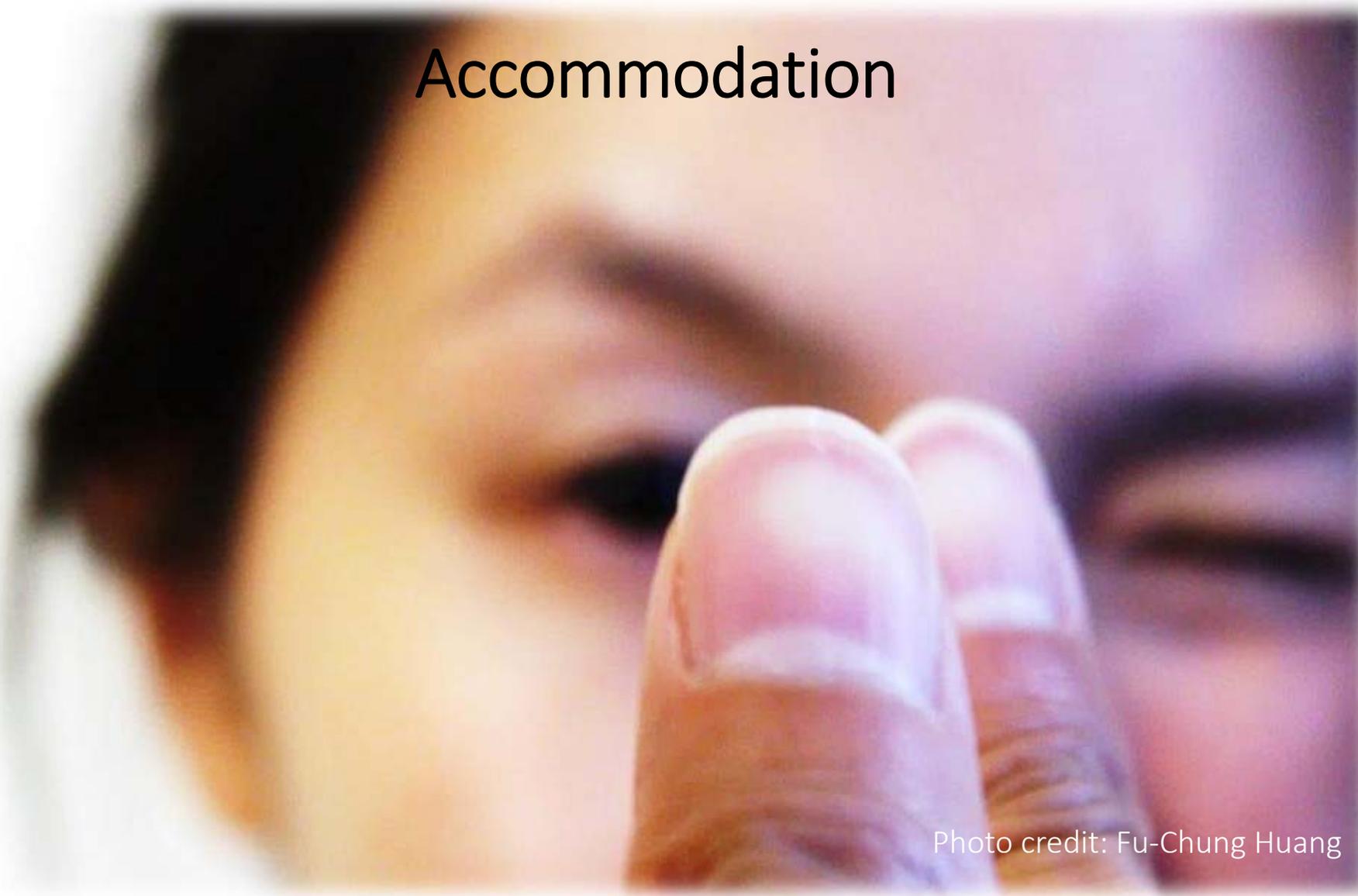
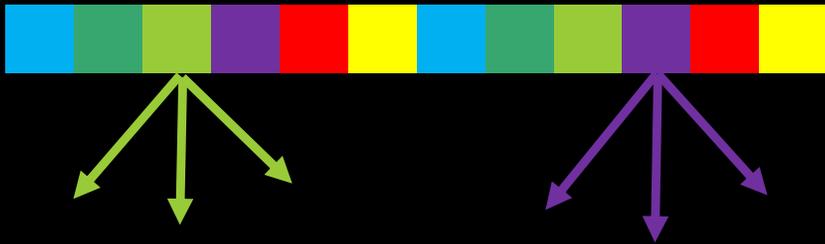


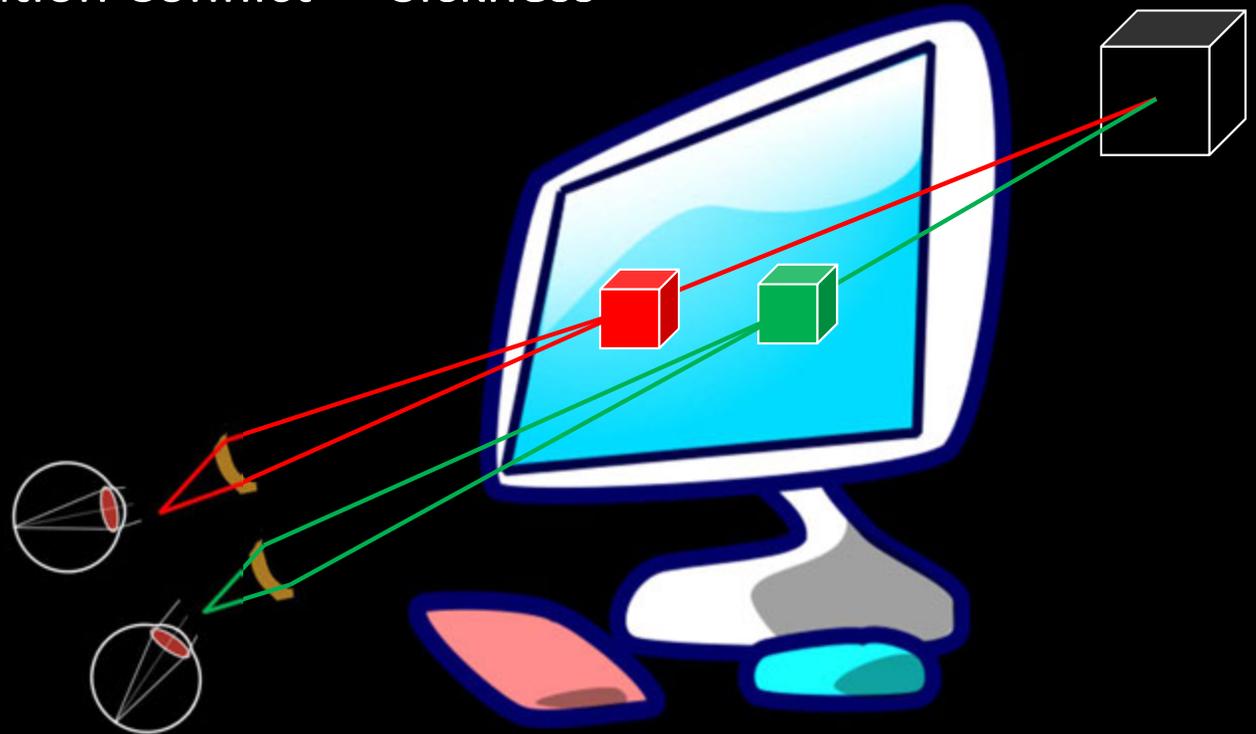
Photo credit: Fu-Chung Huang

Traditional Displays



Critical to Immersive Media

- Vergence–Accommodation Conflict -> Sickness



Critical to Immersive Media

- Vergence–Accommodation Conflict -> Sickness
- Depth Understanding, esp. AR/MR



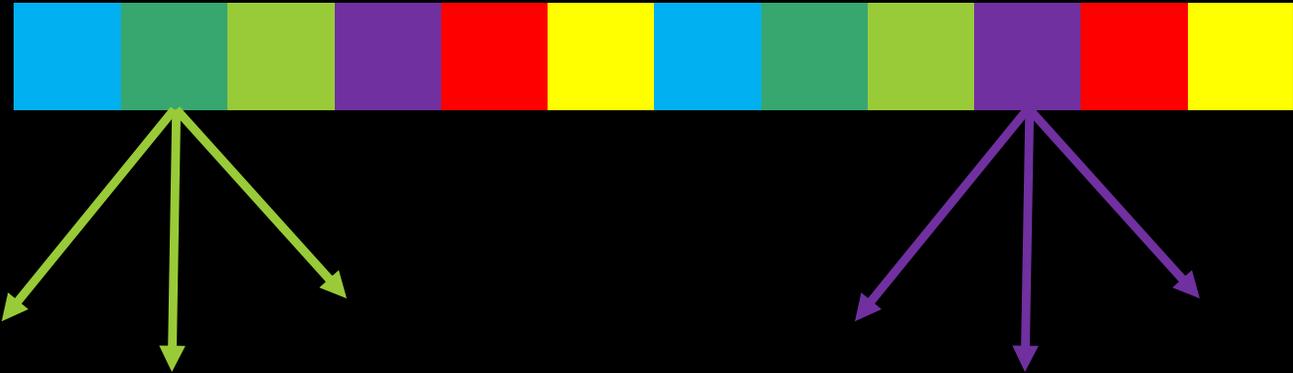
Wide Field Of View Varifocal Near-eye Display Using See-through Deformable Membrane Mirrors, Dunn et al. 2017

Critical to Immersive Media

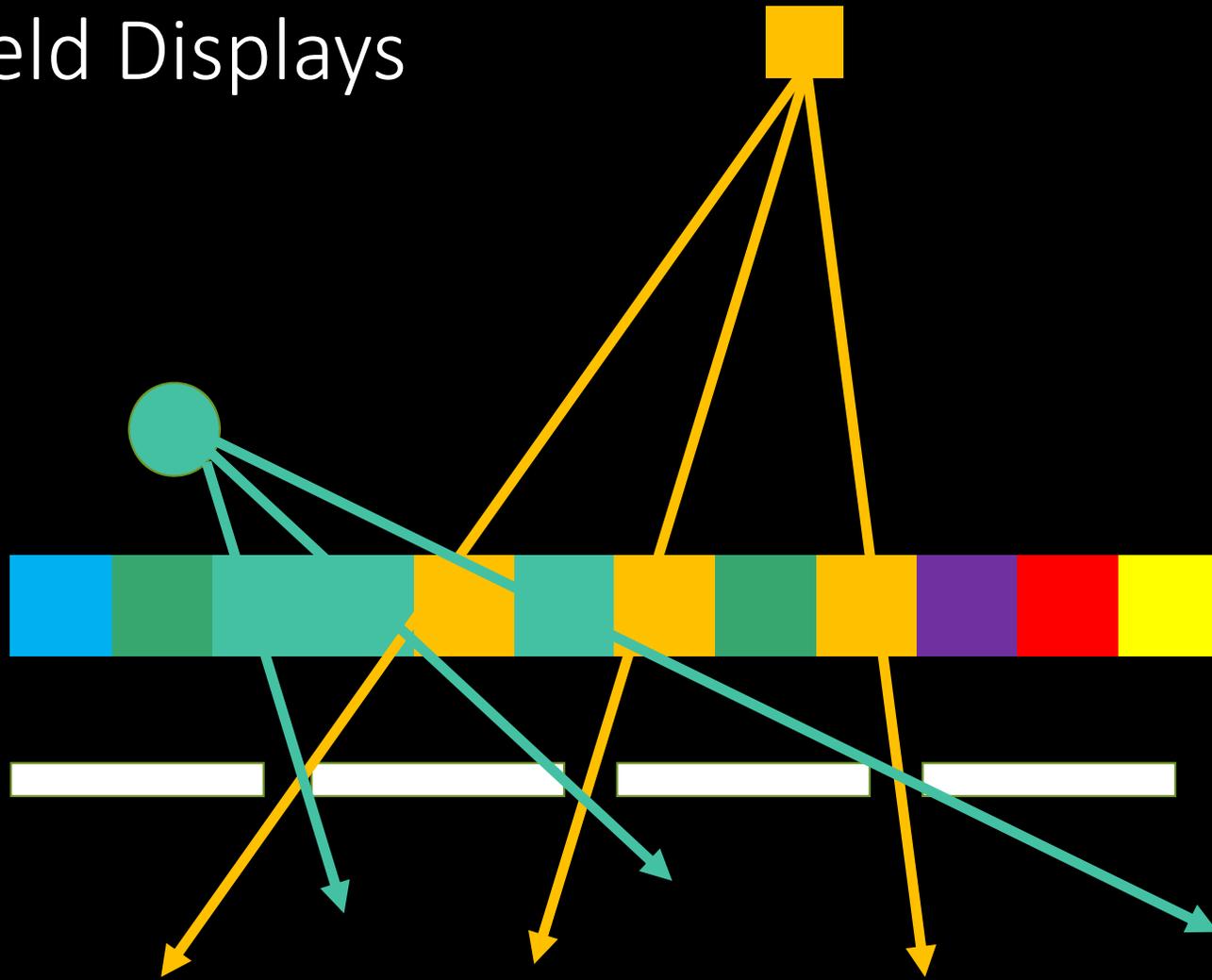
- Vergence–Accommodation Conflict -> Sickness
- Depth Understanding, esp. AR/MR
- Interaction Accuracy



Traditional Displays



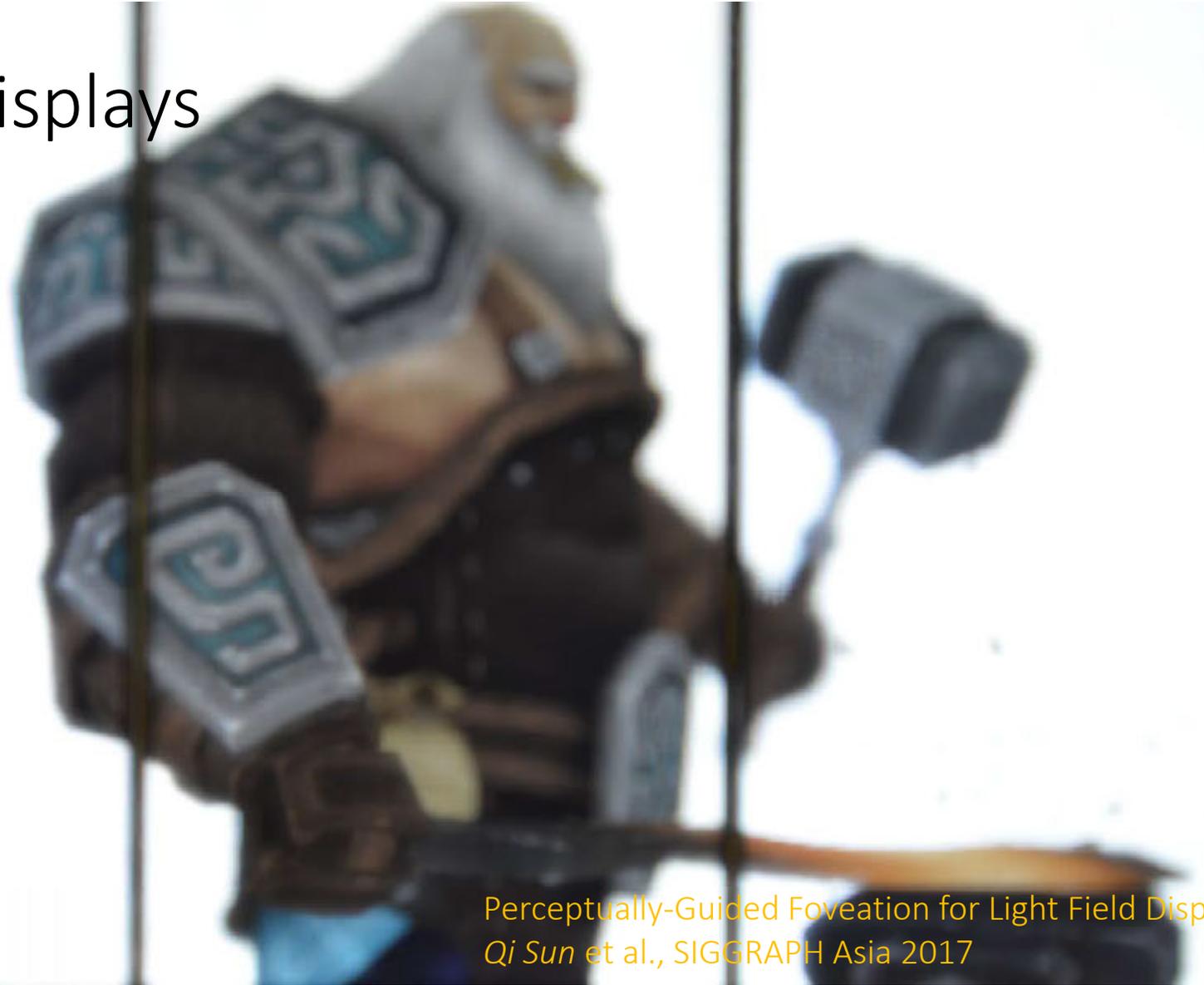
Light Field Displays





Perceptually-Guided Foveation for Light Field Displays
Qi Sun et al., SIGGRAPH Asia 2017

Light Field Displays



Perceptually-Guided Foveation for Light Field Displays
Qi Sun et al., SIGGRAPH Asia 2017

Light Field Displays



Perceptually-Guided Foveation for Light Field Displays
Qi Sun et al., SIGGRAPH Asia 2017

Light Field Displays

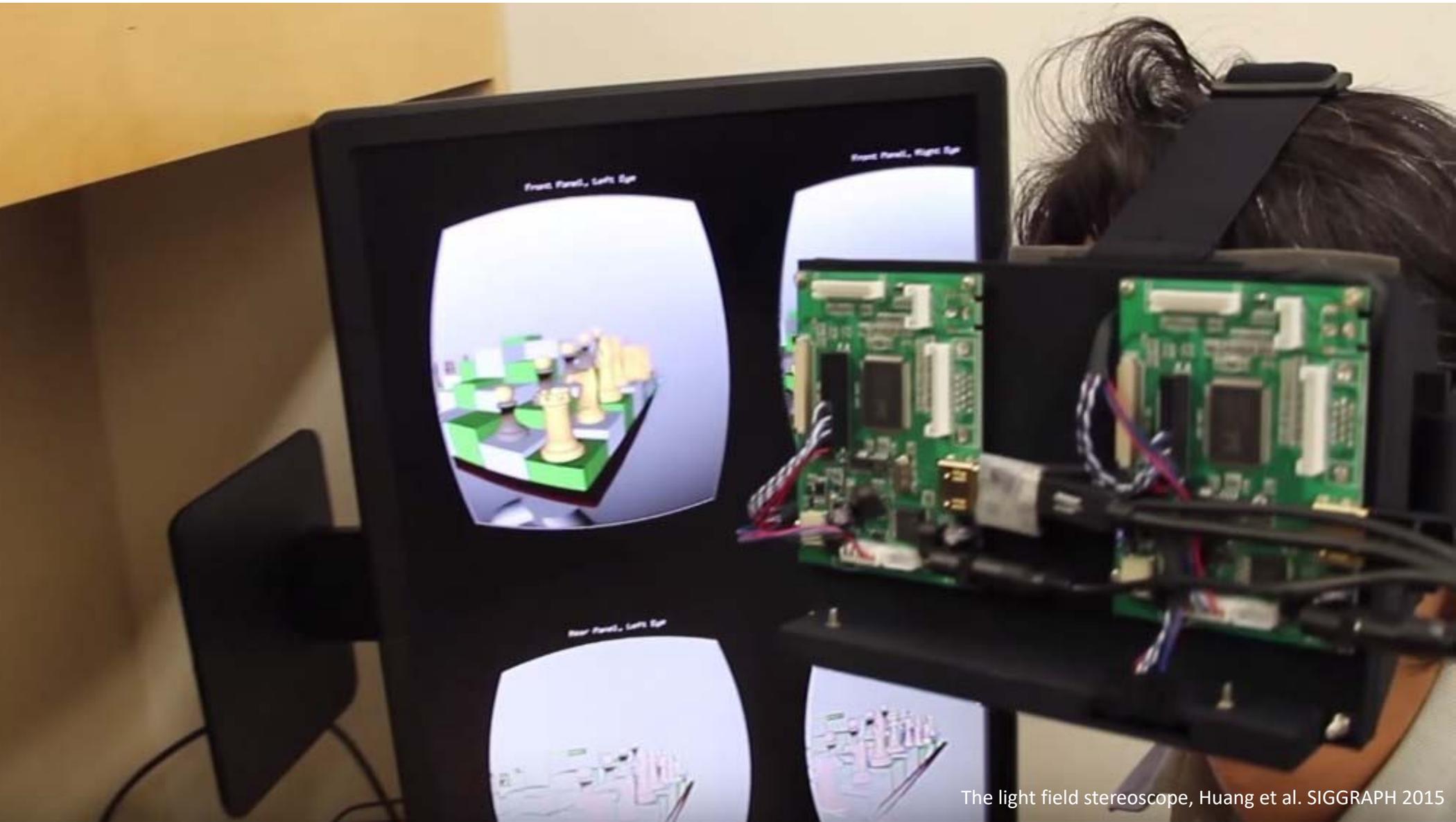


Perceptually-Guided Foveation for Light Field Displays
Qi Sun et al., SIGGRAPH Asia 2017

Light Field Displays



Perceptually-Guided Foveation for Light Field Displays
Qi Sun et al., SIGGRAPH Asia 2017

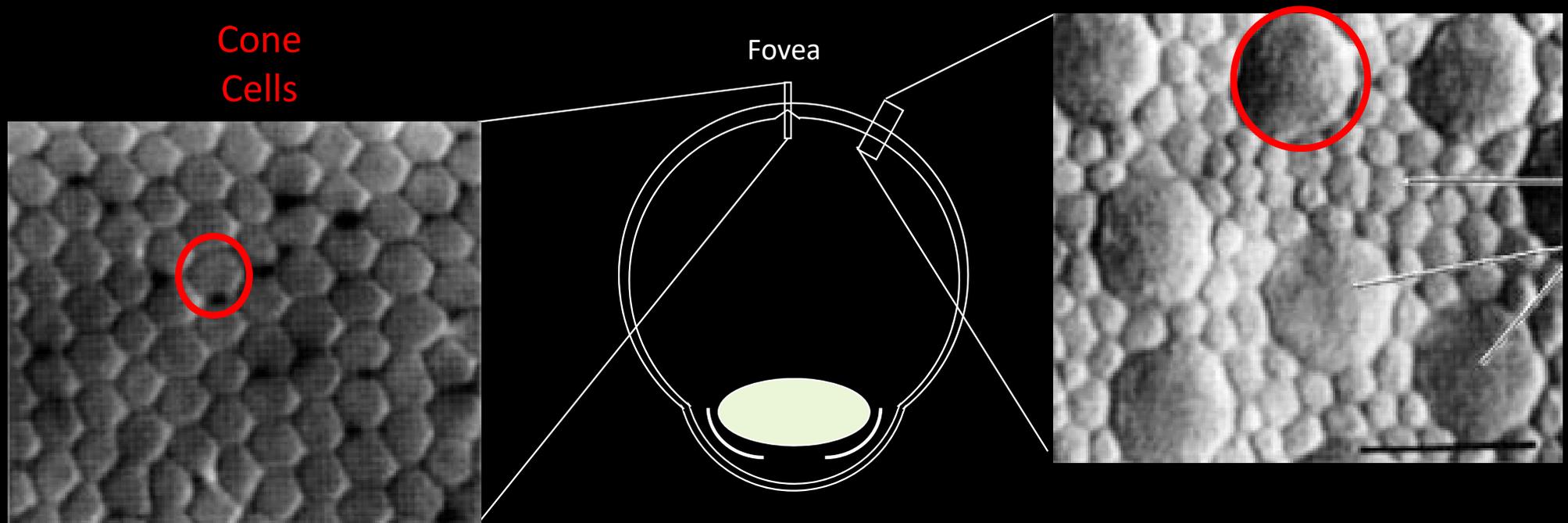


The light field stereoscope, Huang et al. SIGGRAPH 2015

high latency
→ AR/VR sickness



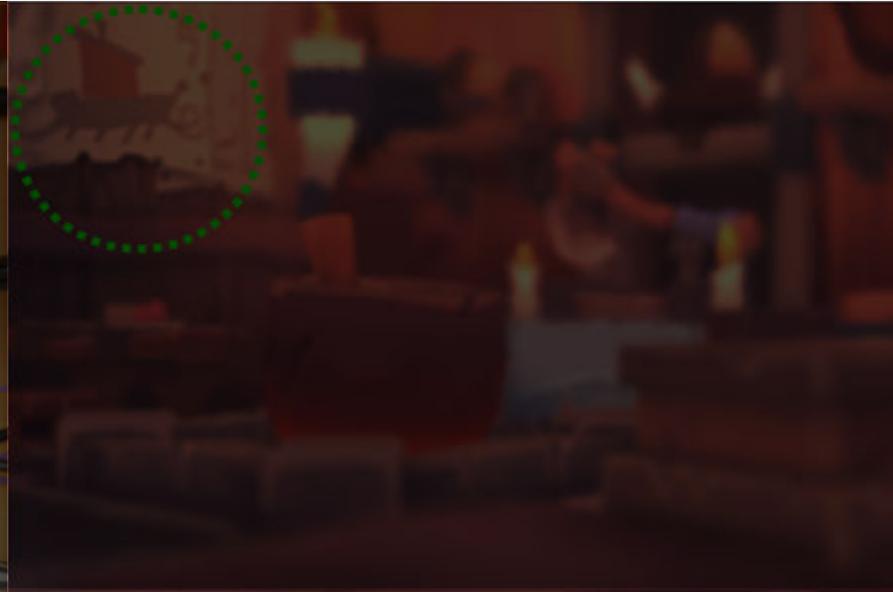
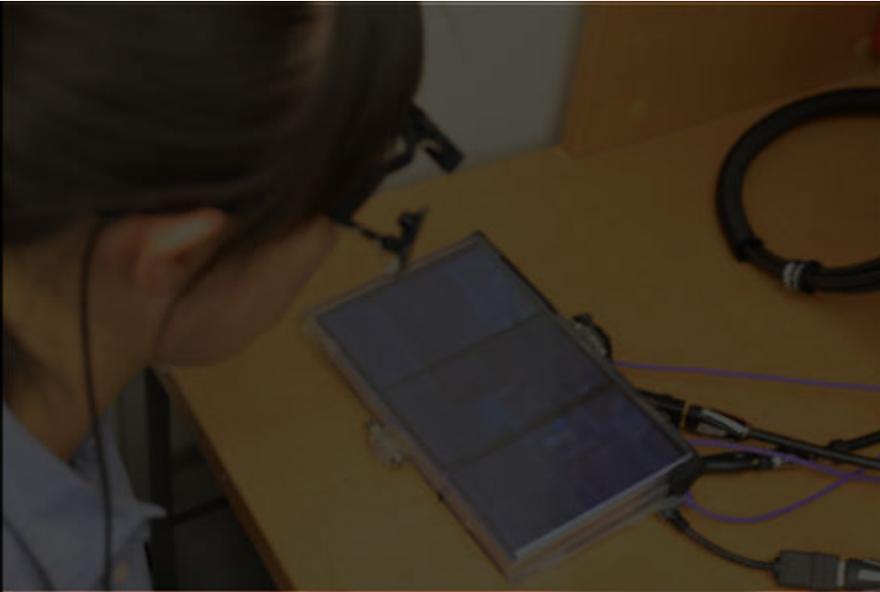
Foveated Human Vision



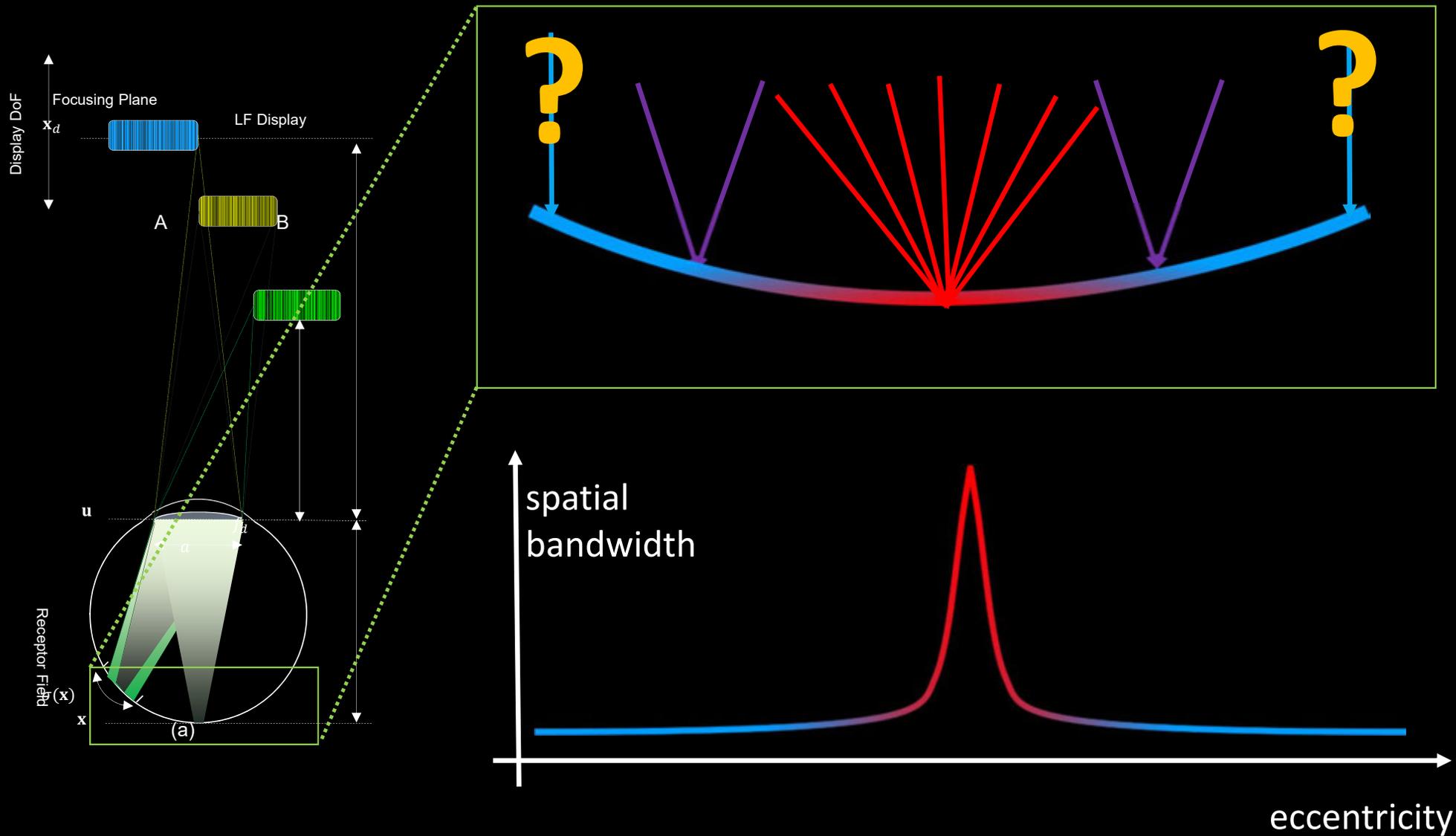


Perceptually-Based Foveated Virtual Reality, Patney et al. 2016

Foveated Light Fields

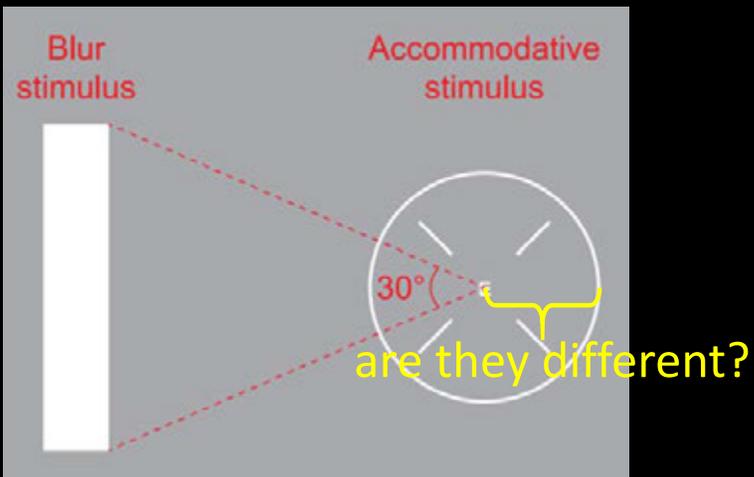


Perceptually-Guided Foveation for Light Field Displays
Qi Sun et al., SIGGRAPH Asia 2017



Psychophysical Studies – Blur Stimuli

Blur Diff Detection

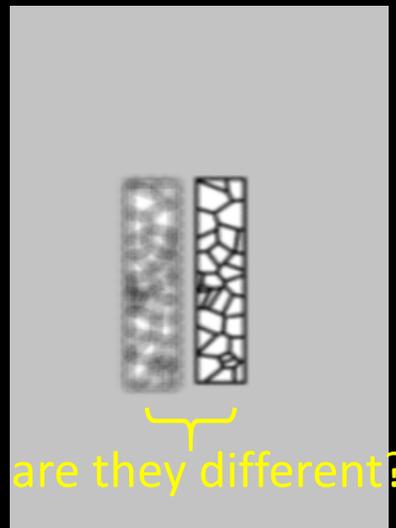




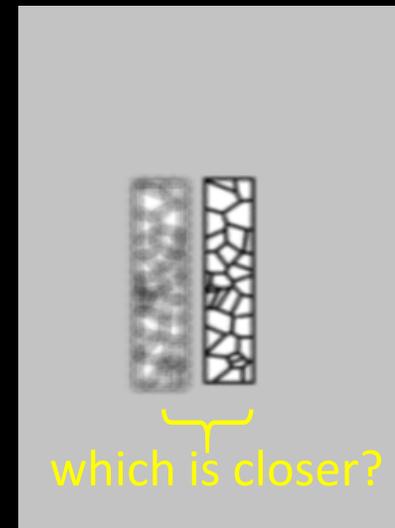
Perceptual Studies for Foveated Light Field Displays
Joohwan Kim et al., arXiv 2017

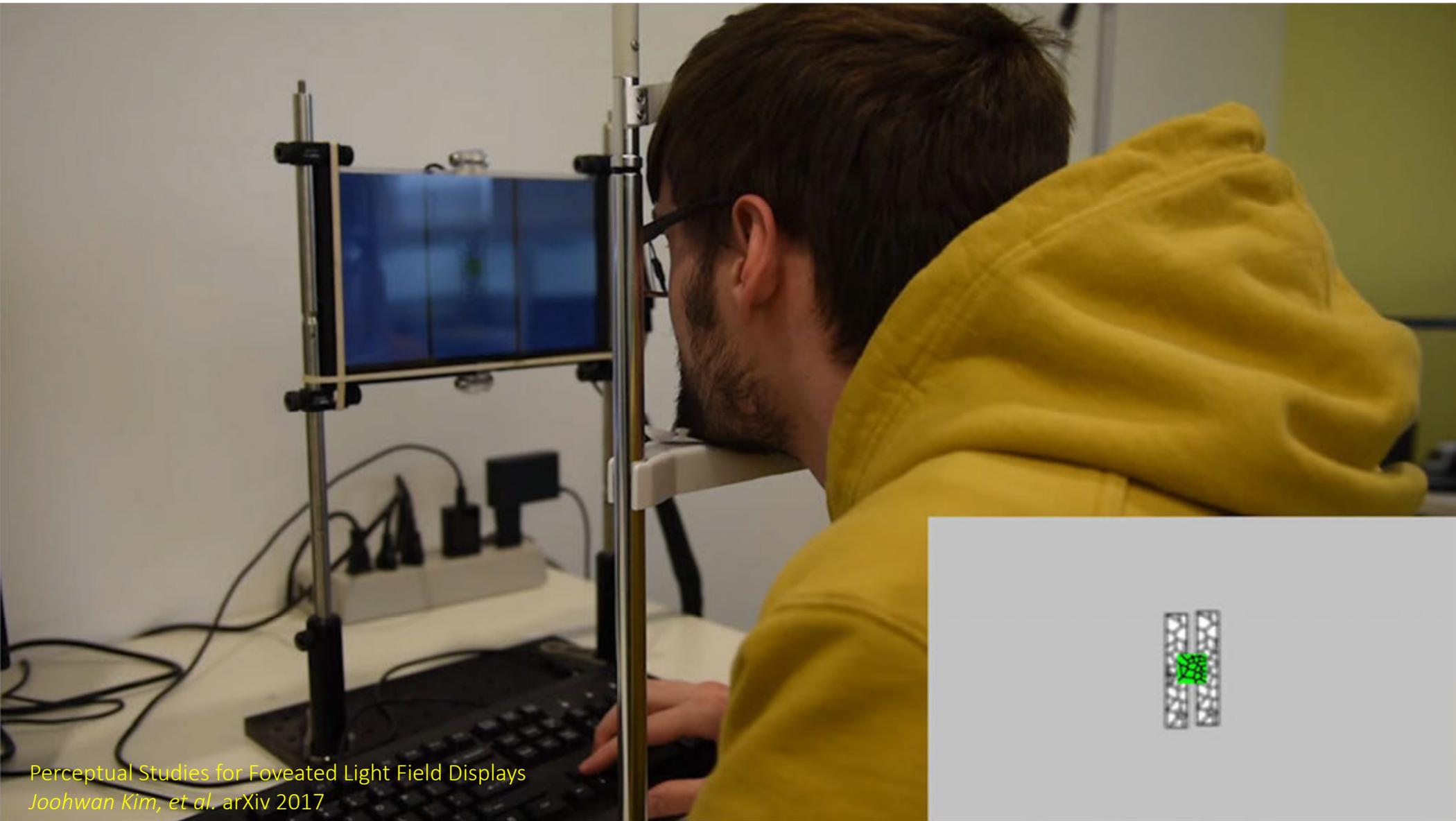
Psychophysical Studies – Light Field Stimuli

Depth Diff
Detection



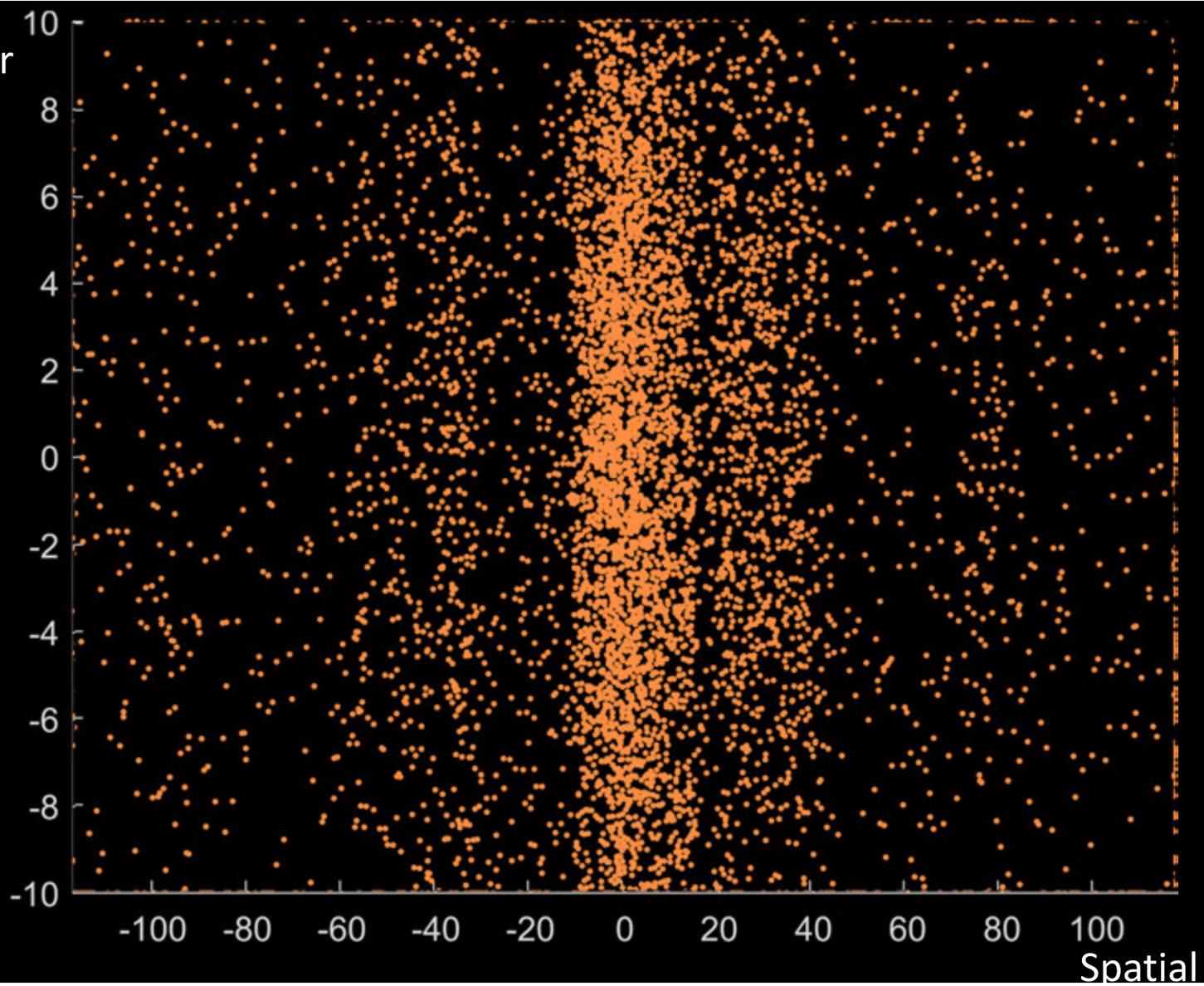
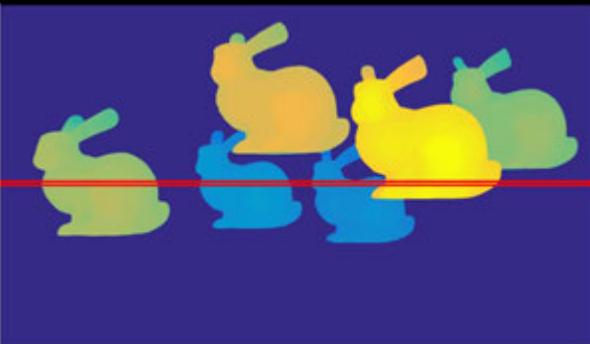
Depth
Discrimination

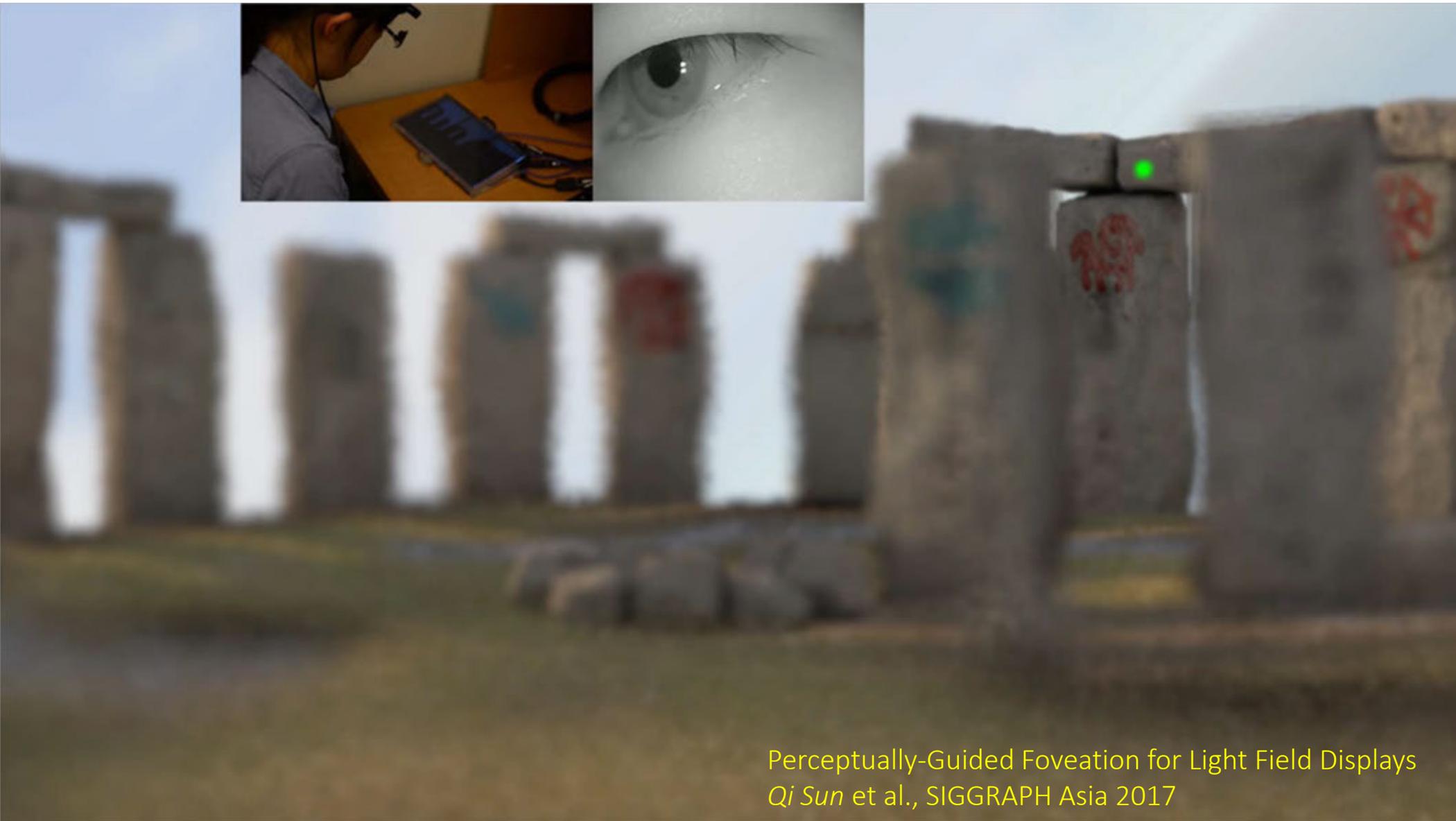




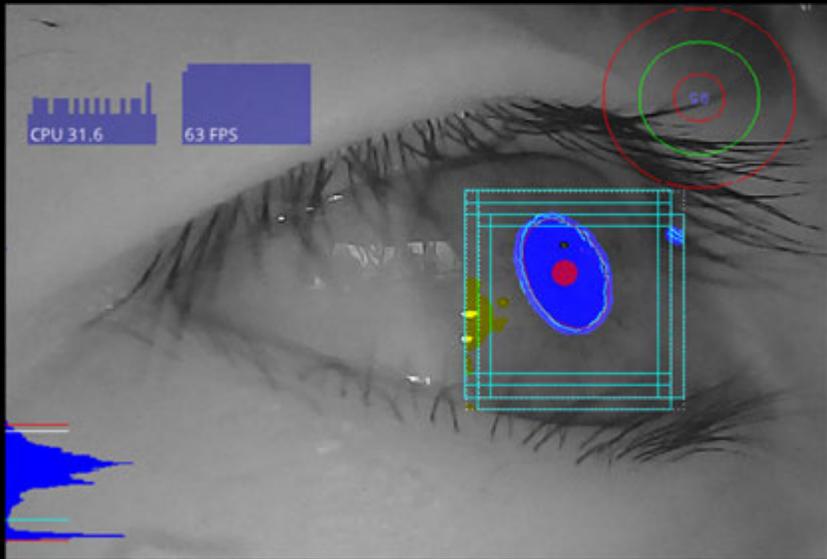
Perceptual Studies for Foveated Light Field Displays
Joohwan Kim, et al. arXiv 2017

Angular





Perceptually-Guided Foveation for Light Field Displays
Qi Sun et al., SIGGRAPH Asia 2017



foveated light field

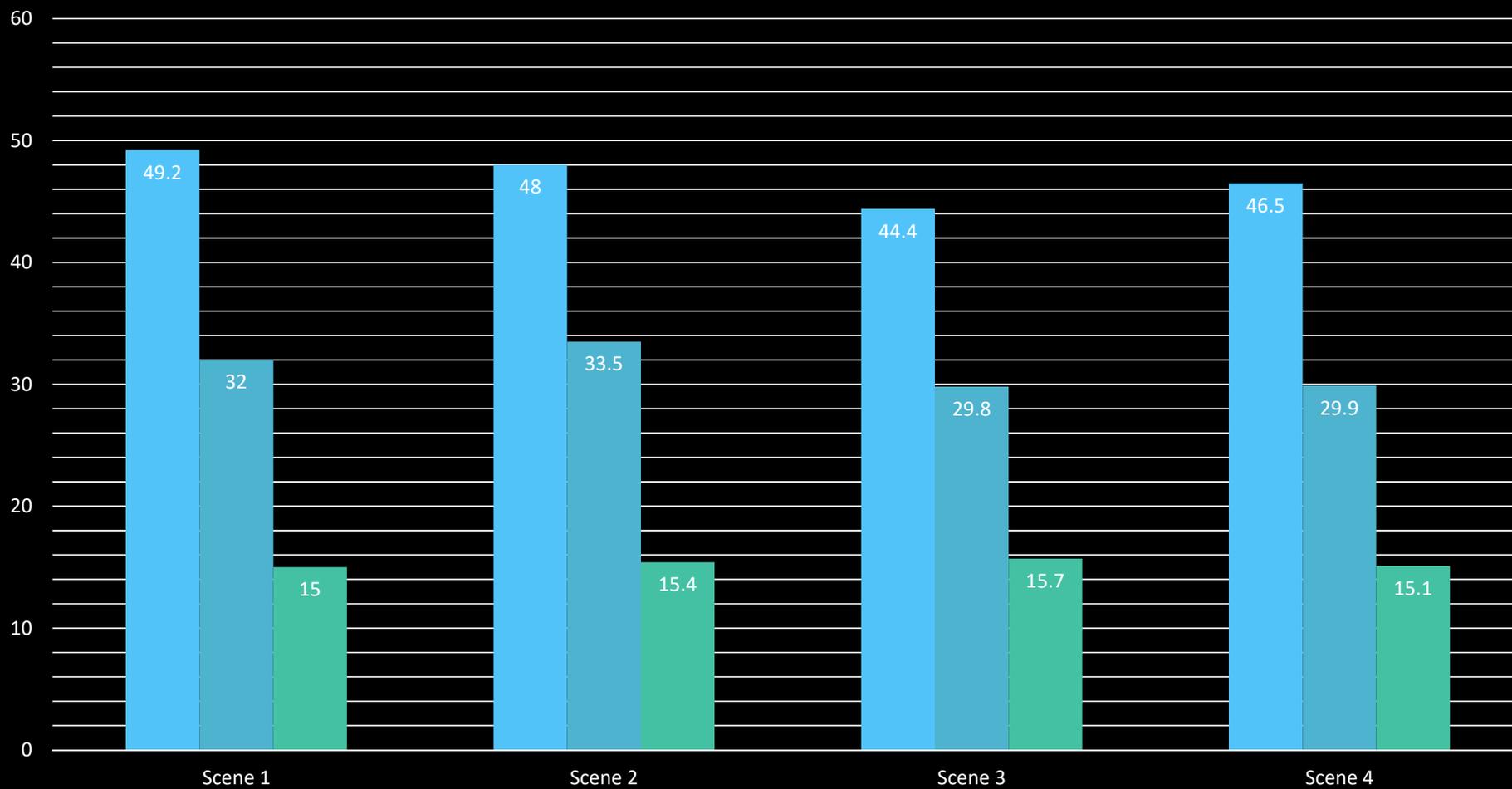


full light field



FPS

■ Ours ■ Full resolution ■ [Huang et al. 2015]

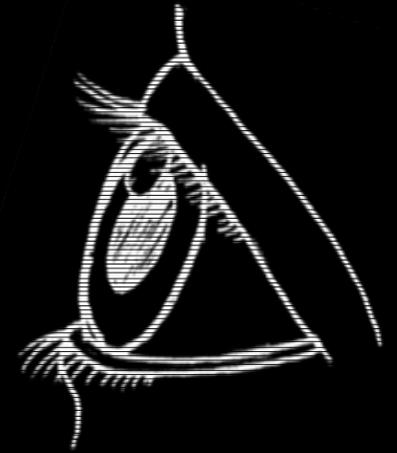


What we see

- Track, understand, analyzing the anatomical eyes

→ Faster, more comfortable, natural

→ Content representation/authorization/viewing



What's Next?

Eye-Tracked Immersive Perception

- Foveal VS peripheral vision
 - Perception of dynamics
 - Immersive media interface
 - Cinematography

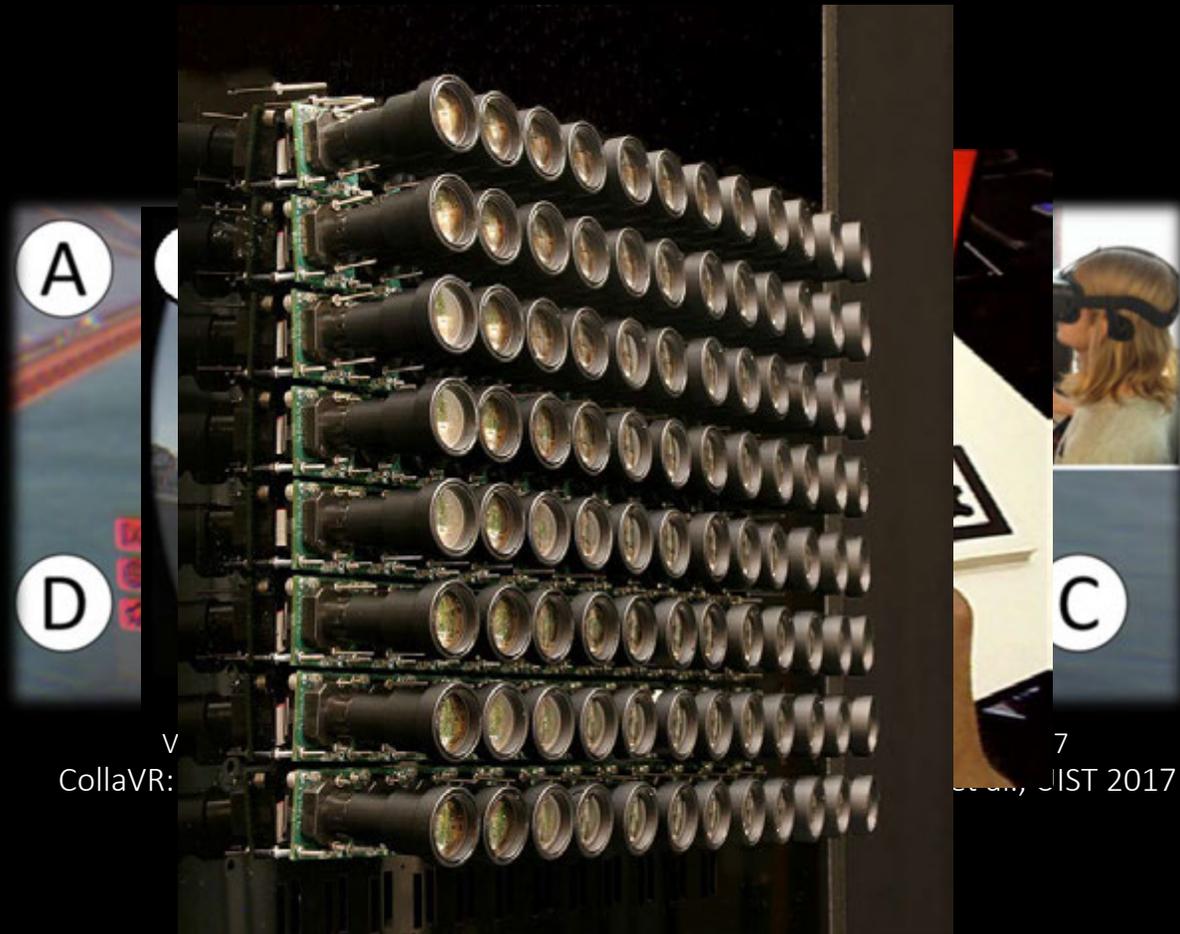
Why Important?

- Other actions
 - Vergence
 - Blink



Perception-assisted Immersive Creation

- Immersive media editing
- Painting/Sculpting
- Light Field Capturing
- Collaborative authorization



Thank You!
&
Discussion

More Materials: <http://qisun.me/>

Major References:

- Mapping Virtual and Physical Reality. *Qi Sun, Li-Yi Wei, and Arie Kaufman, SIGGRAPH 2016*
- Perceptually-Guided Foveation for Light Field Displays. *Qi Sun, Fu-Chung Huang, Joohwan Kim, Li-Yi Wei, David Luebke, and Arie Kaufman, SIGGRAPH Asia 2017*

