



Virtual and Augmented Reality

CS-GY 9223/CUSP-GX 6004

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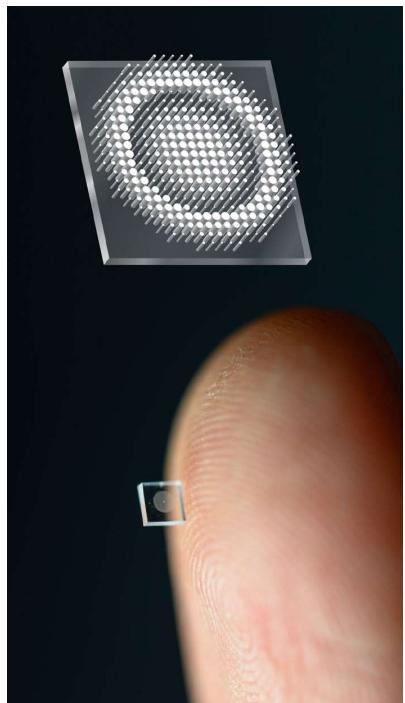
Logistics

Assignment 2 released

Guest lecture next week

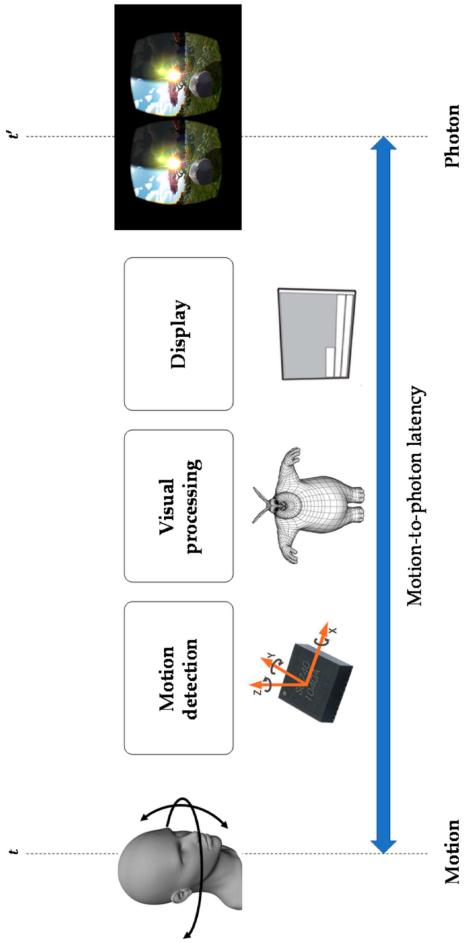


Ethan Tseng, Princeton University



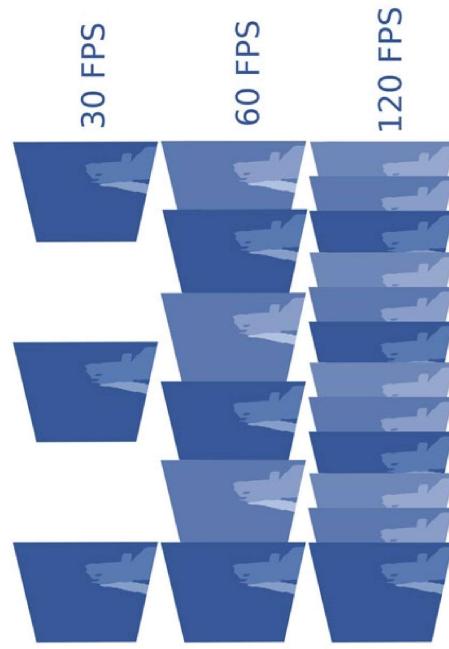
[Assignment Related] Display Performance Metric

1. Motion-to-photon latency



2. Framerate

<https://docs.unity3d.com/ScriptReference/Time-deltaTime.html>

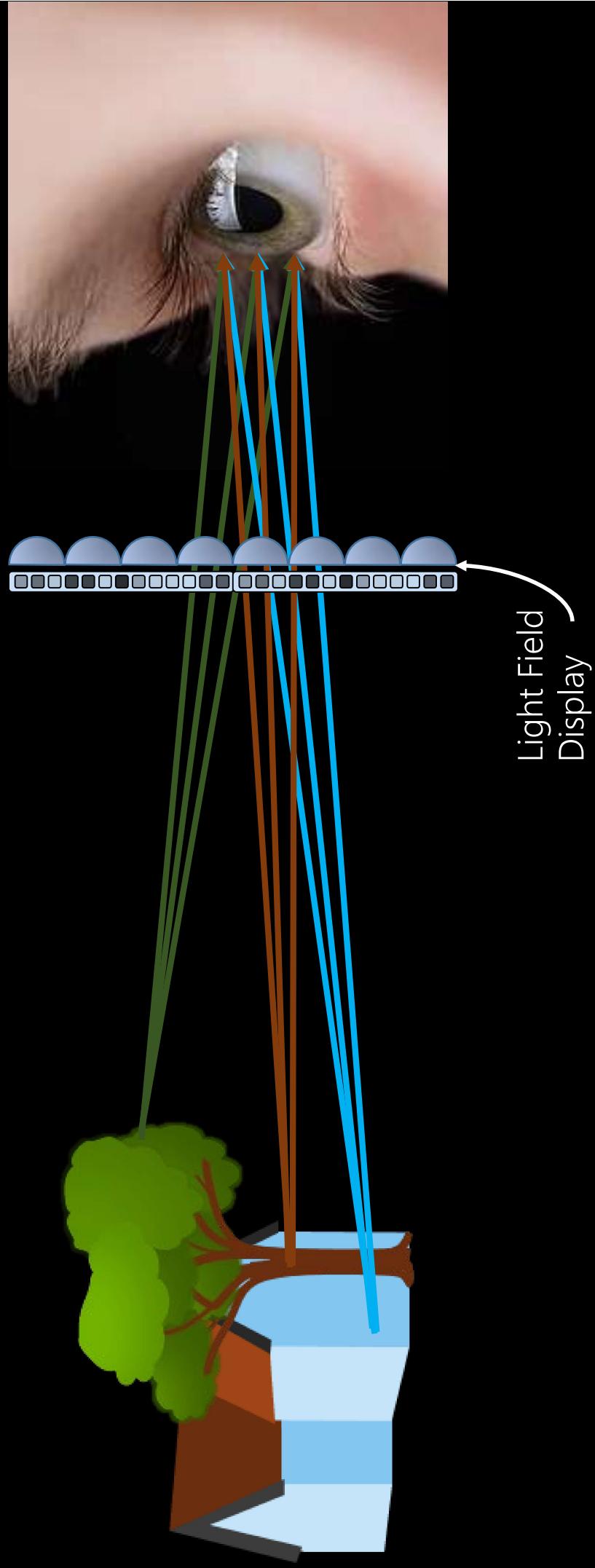




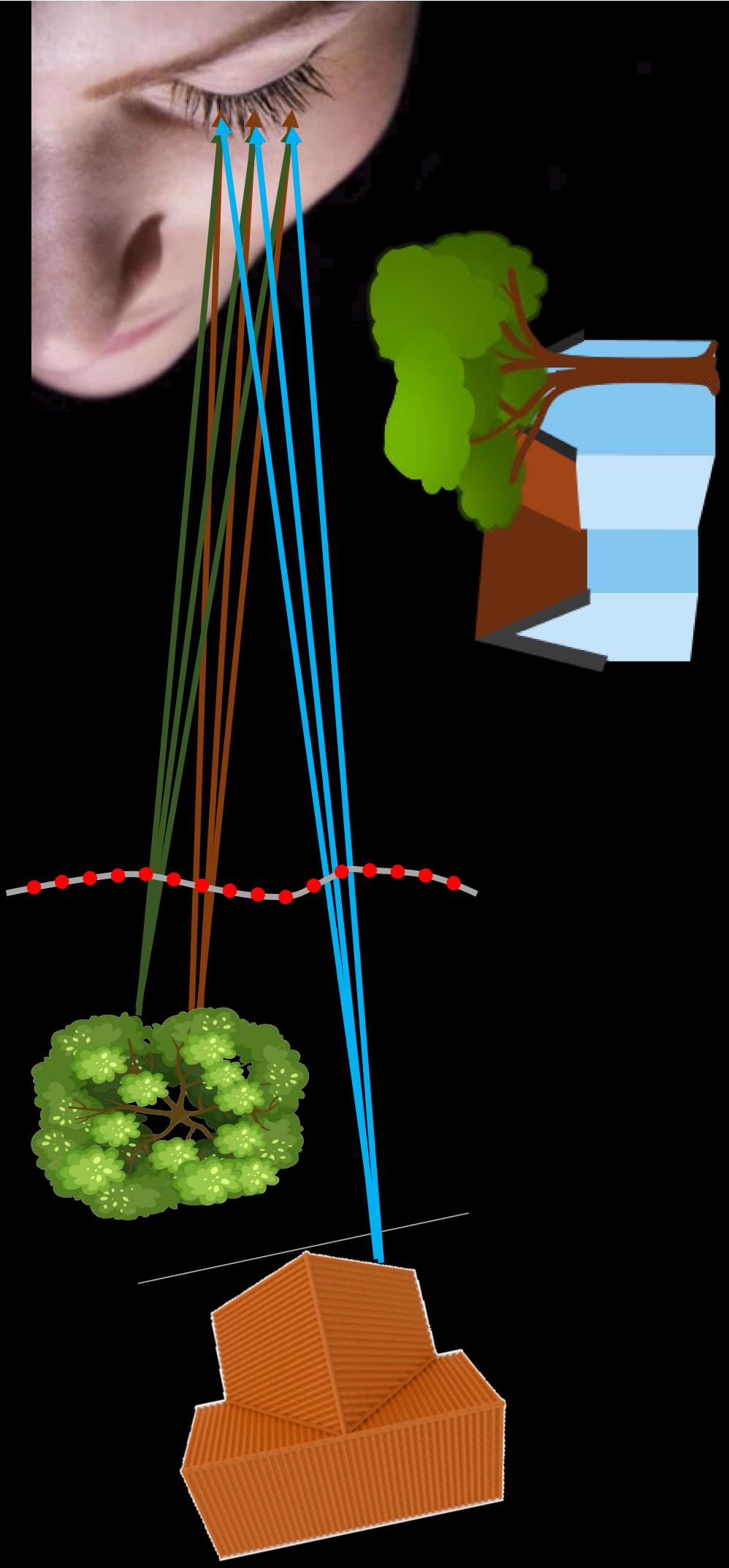


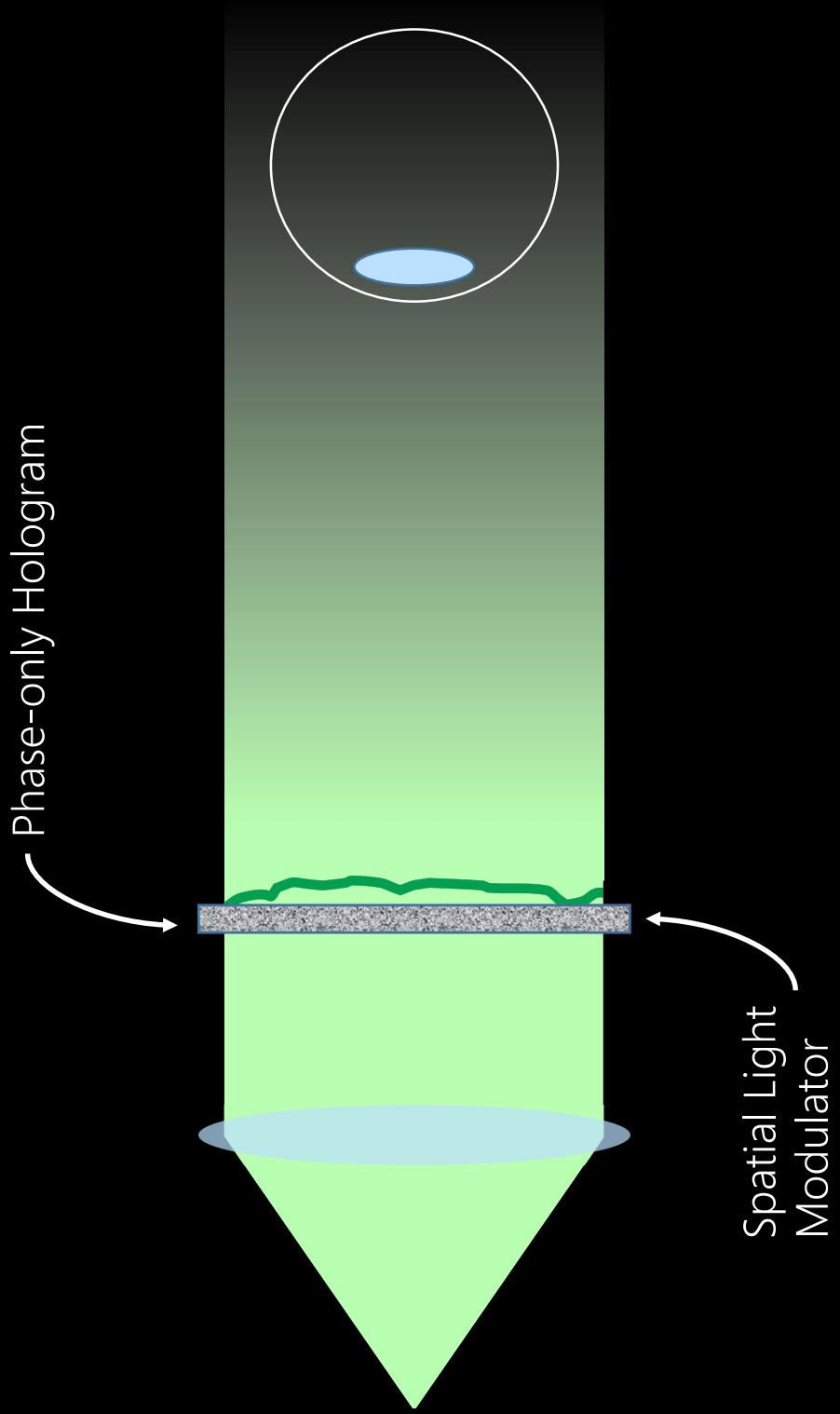


Viewing a 3D Scene

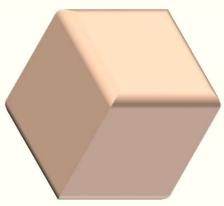


Viewing a 3D Scene

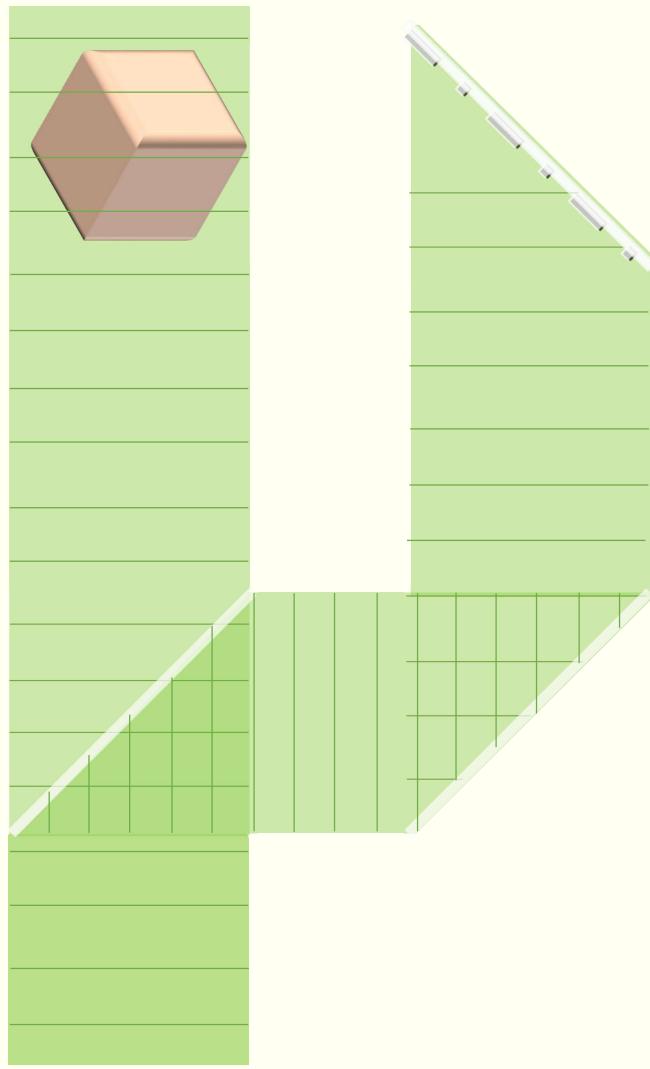




Principle of Holography

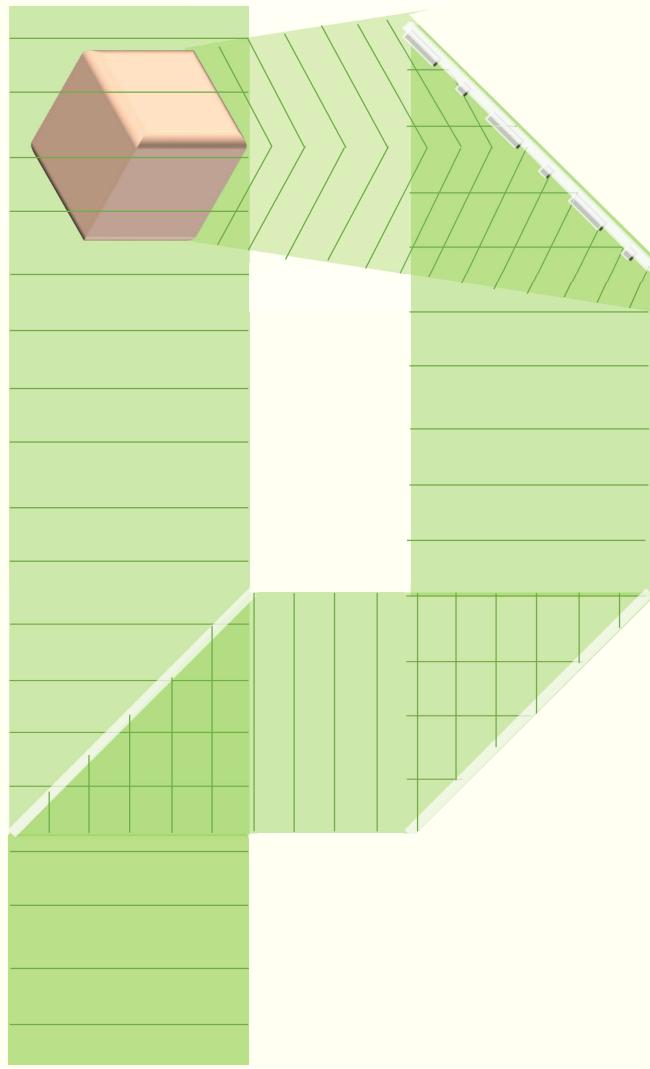


Principle of Holography



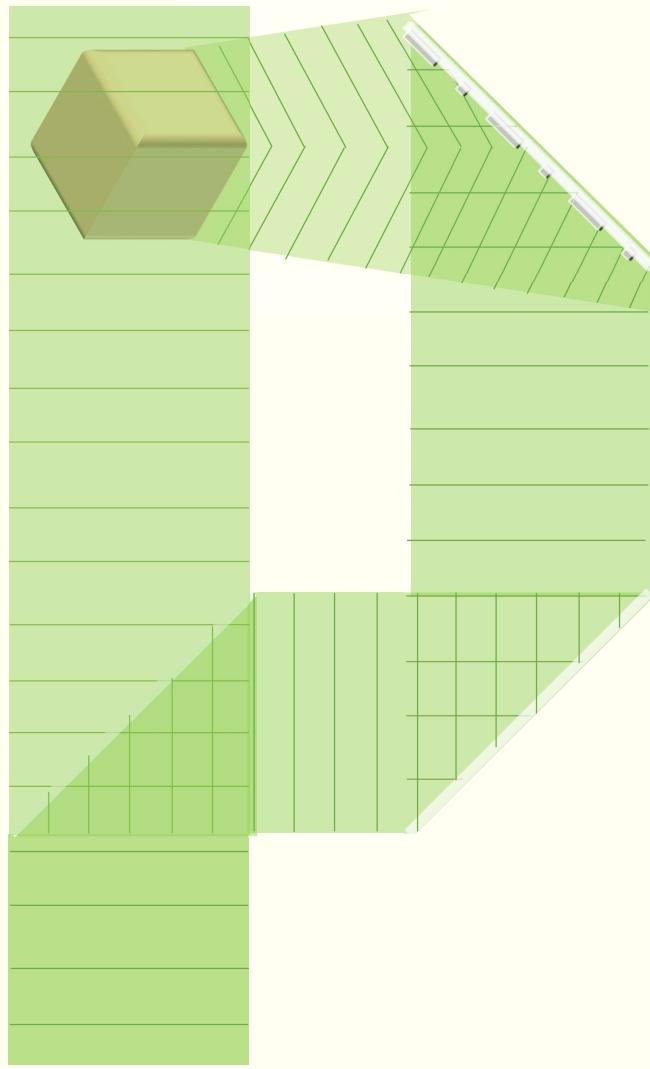
Step 1: Recording

Principle of Holography

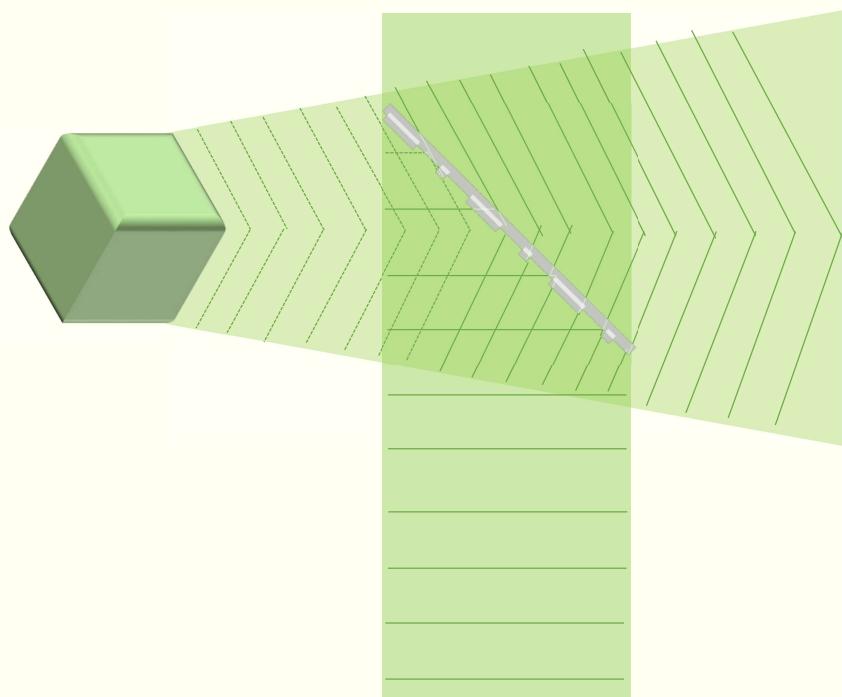


Step 1: Recording

Principle of Holography

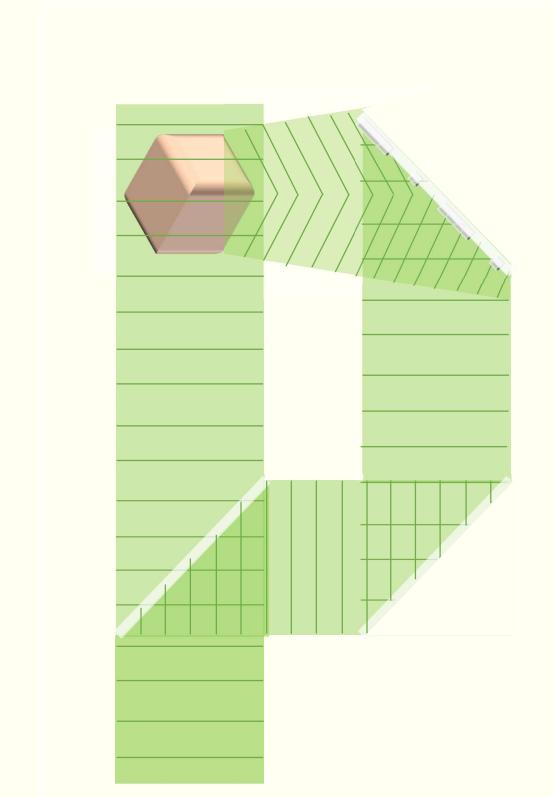


Step 1: Recording



Step 2: Playback

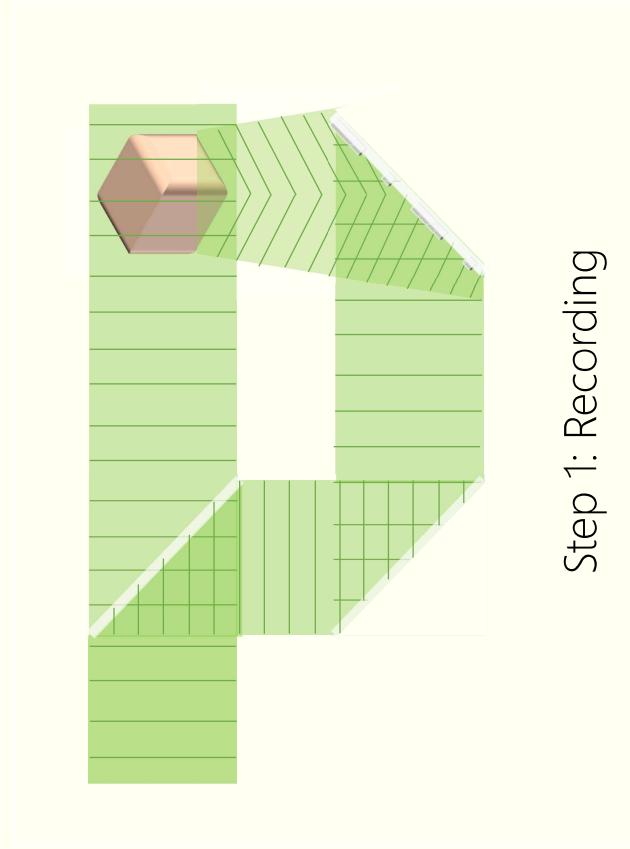
Principle of Holography



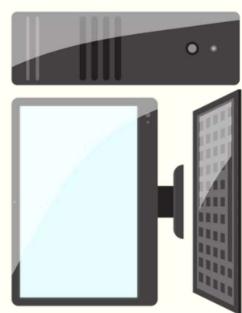
Step 1: Recording



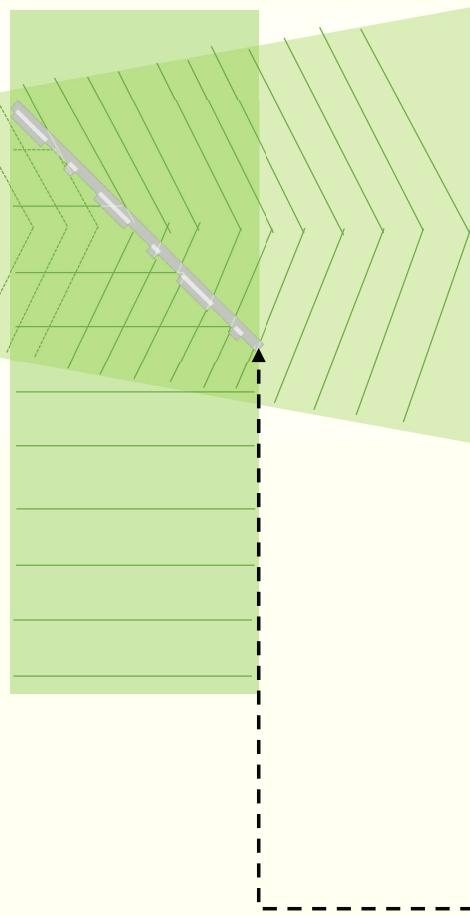
Principle of Holography



Step 1: Recording

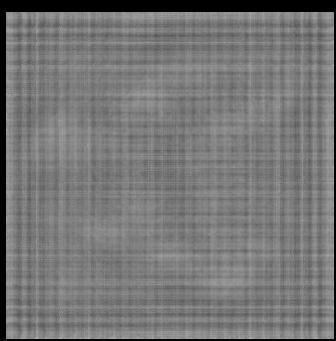


Step 2: Playback



Wirtinger Gradient-based Optimized Holograms

Phase Hologram Target Reconstruction



$$\mathcal{L}($$

$$H(\Phi) = c \exp^{j\Phi}$$

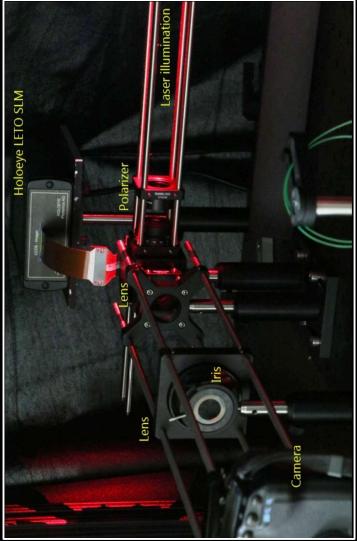
$$Err = f(|z|^2, I) = f(z)$$

$$z = \mathcal{P}(H)$$

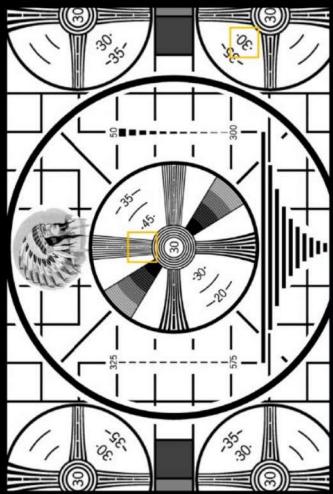


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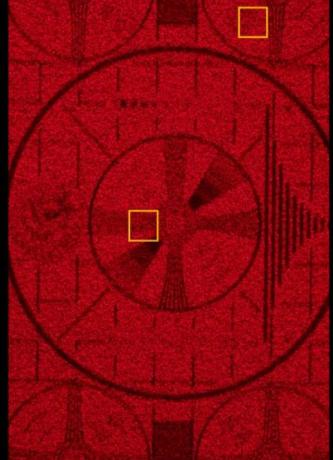
Captured 2D Holograms on Holographic Display



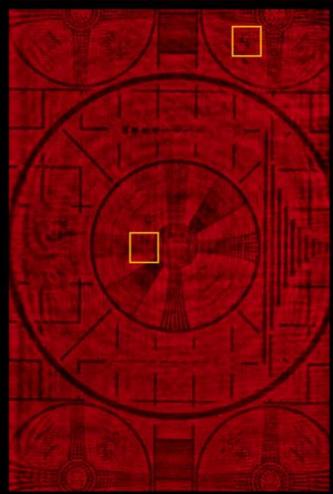
Target



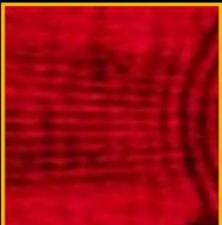
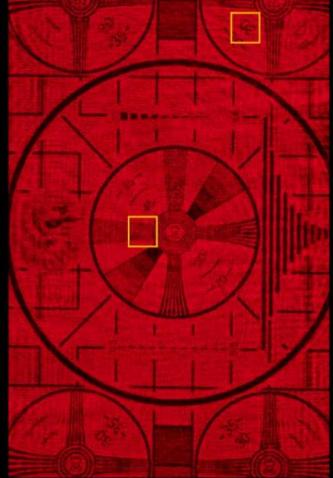
Modified GS
(Peng et al. 2017)



Double phase
(Maimone et al. 2017)

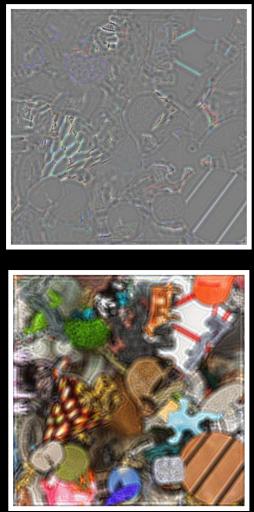
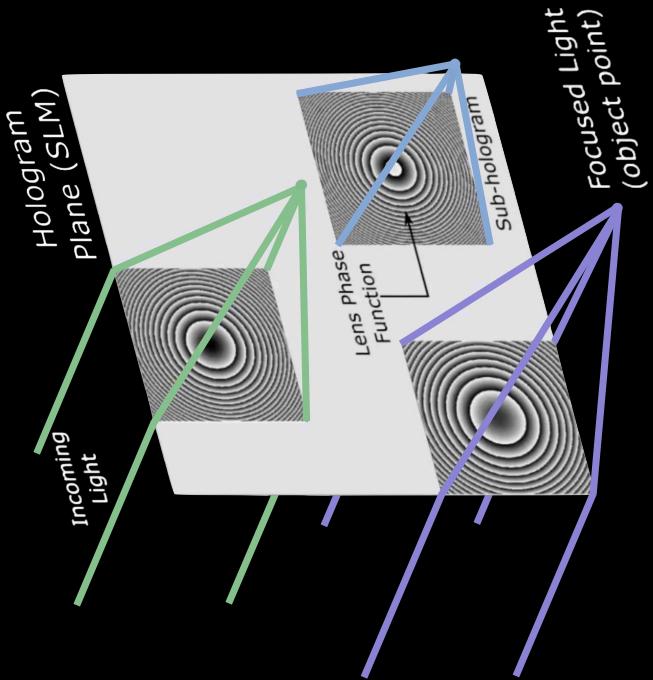


Our Method



Wirtinger Holography for Near-eye Displays, SIGGRAPH Asia 2019

Computing True 3D Holograms



Target 3D Point Cloud

Complex Hologram Simulation

Phase Encoding



Hardware-in-the-loop



Holography Basics

2D Holographic Phase Retrieval

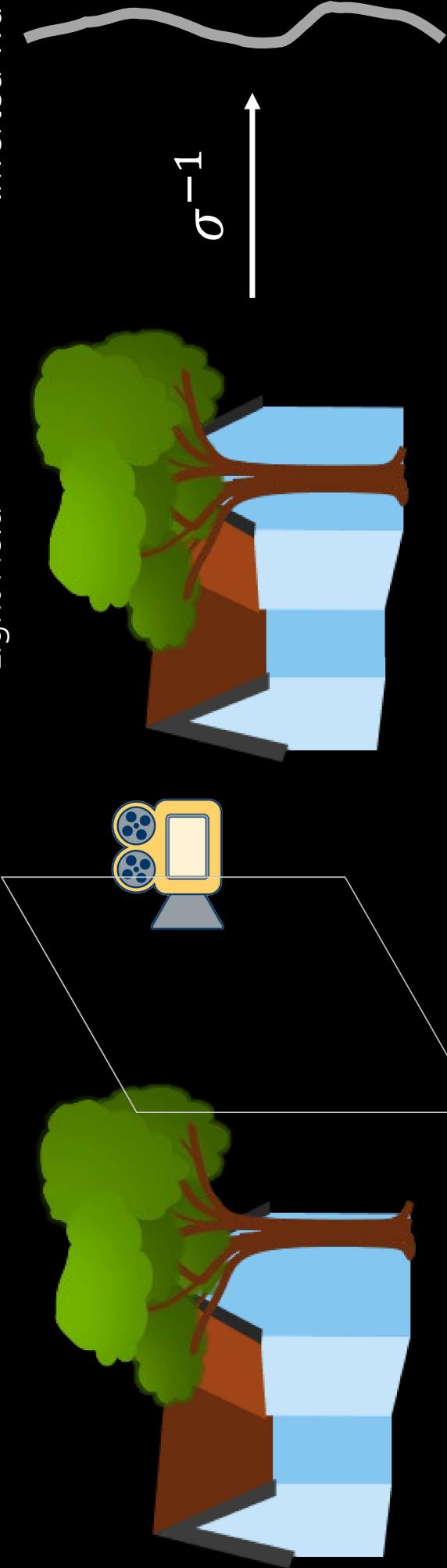
3D Holograms

Hardware-in-the-loop

Inverting Light Field into a Wave Field

Light Field

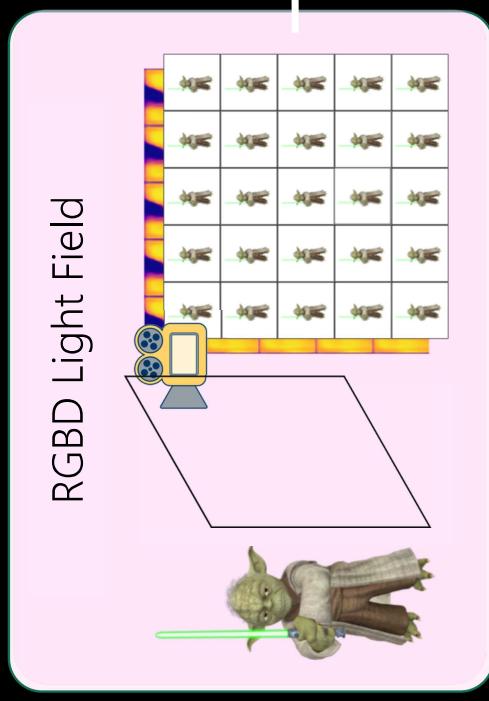
Inverted Wave Field



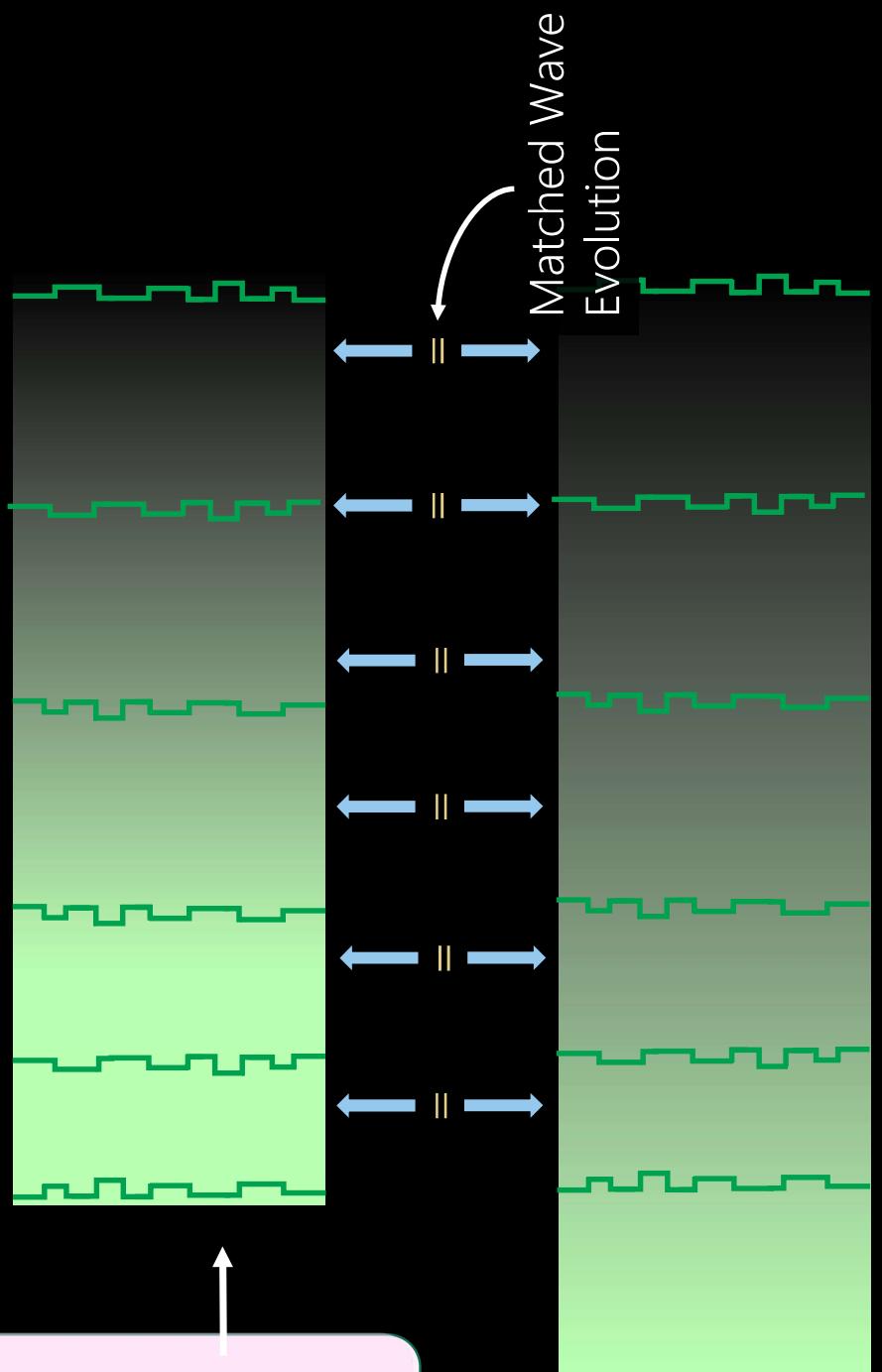
Propagated Wavefront Operator

$$\Phi_{\text{OPT}} = \min_{\Phi} \left\| \mathcal{P}(e^{j\Phi}, z_{\text{WR}}) - \sum_{(\theta_x, \theta_y)} \sigma_{(\theta_x, \theta_y)}^{-1} \left\{ \sqrt{L(\theta_x, \theta_y)} e^{j\Psi(\theta_x, \theta_y)} \right\} \right\|$$

Continuous Volume Wavefront Optimization



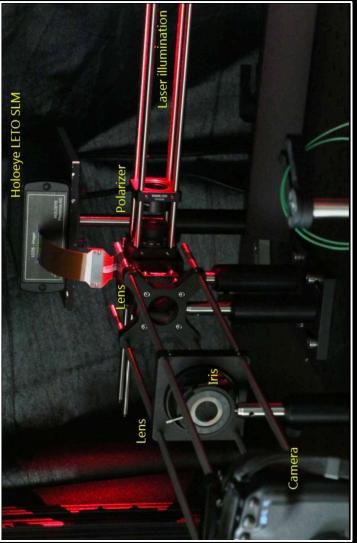
Phase Hologram



$$\Phi_{\text{OPT}} = \min_{\Phi} \int_V \mathcal{L} \left(|\varphi(e^{j\Phi}, z_{\text{WR}} + z)|, |\varphi(U_{\text{WR}}, z)| \right) dz,$$

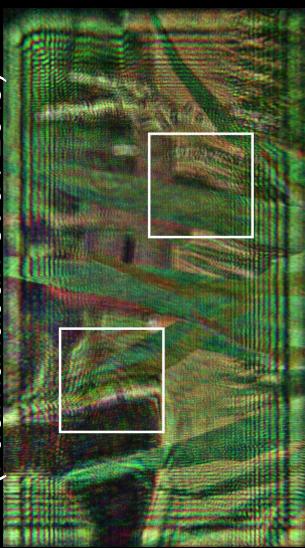
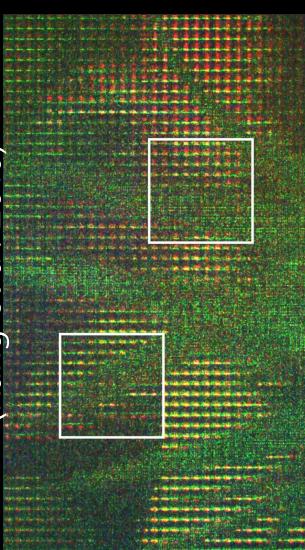


Captured 3D Holograms on Holographic Display

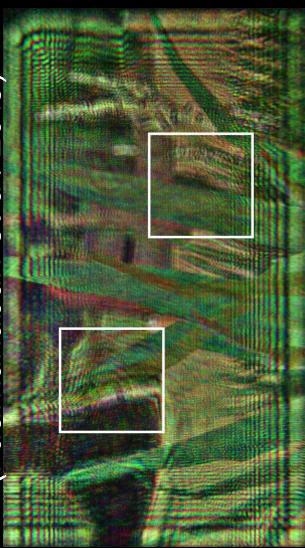


Near Focus

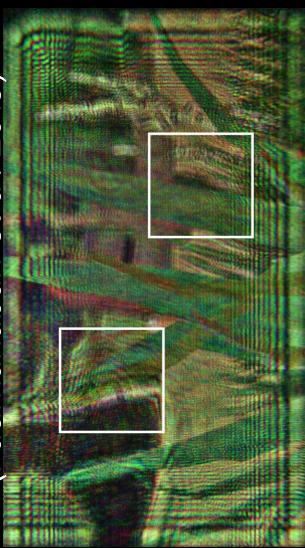
Phase Add Stereograms
(Kang et al. 2016)



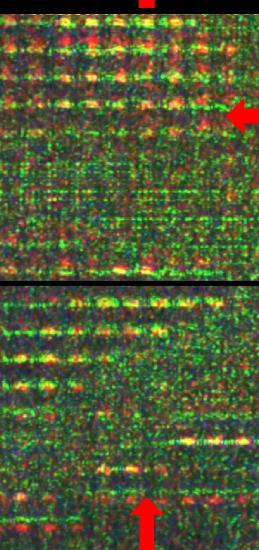
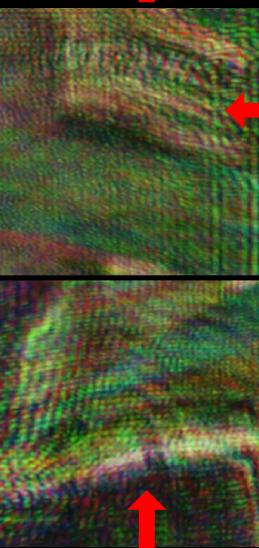
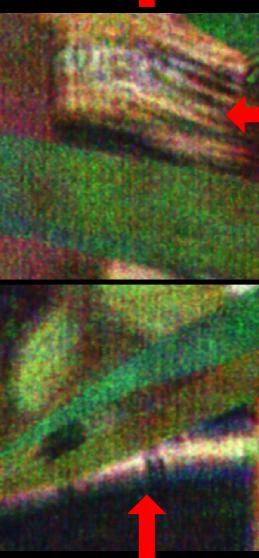
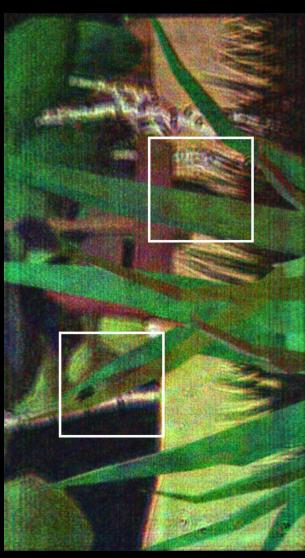
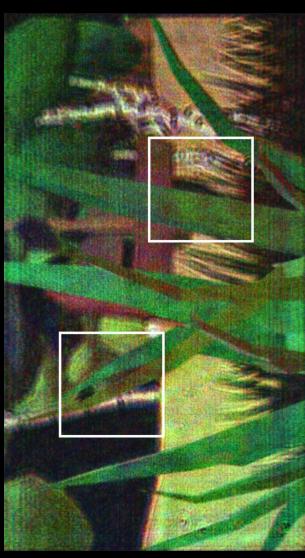
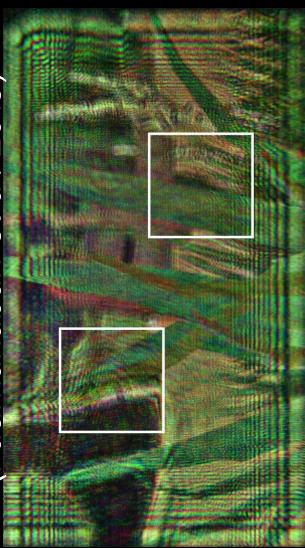
Overlap Add Stereograms
(Padmanabhan et al. 2019)



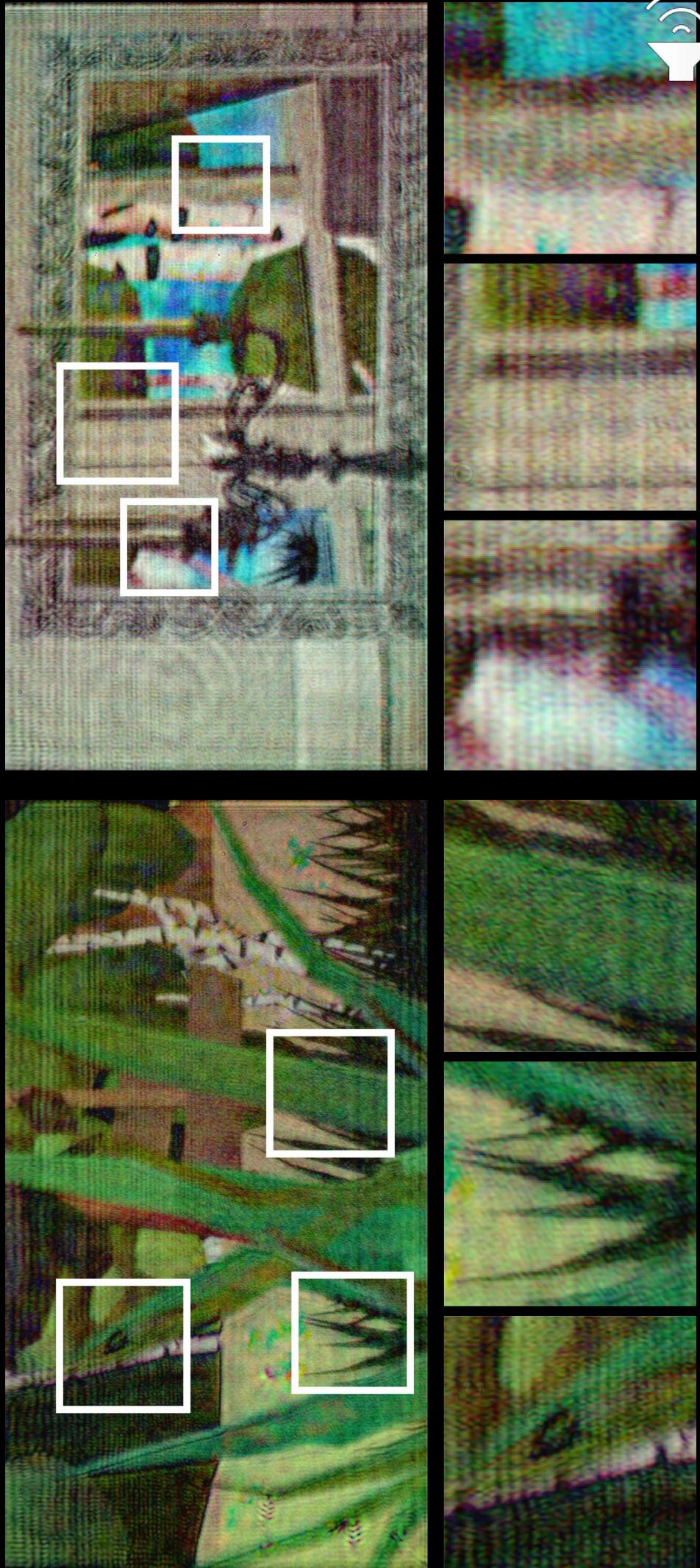
Our Method



Target

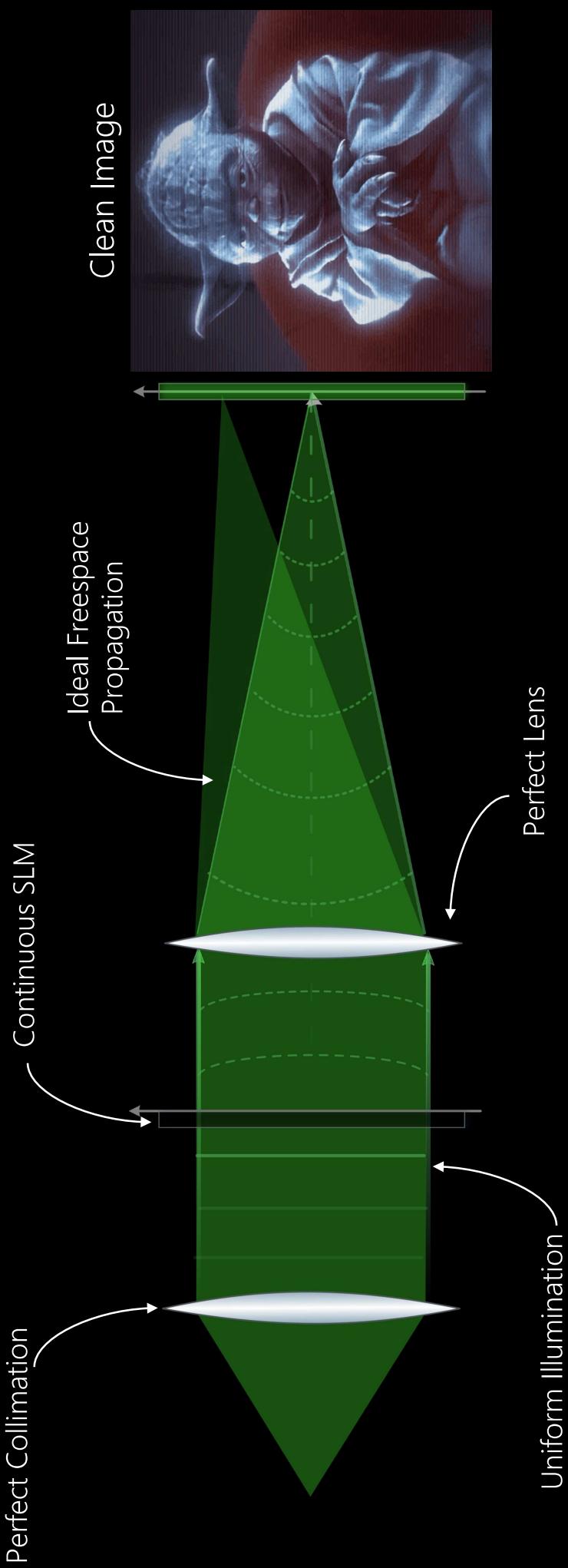


Right View

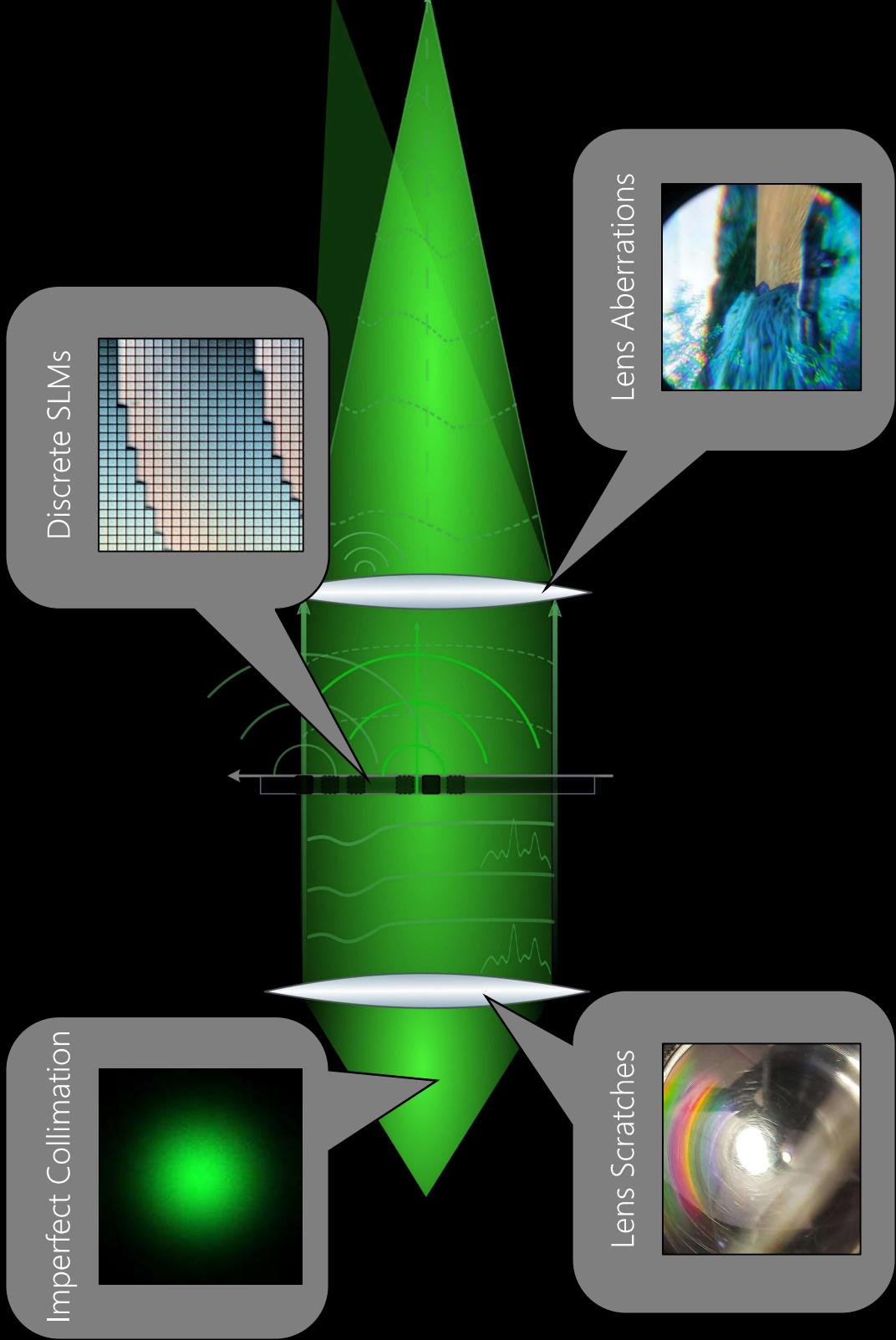




Ideal Holographic Display

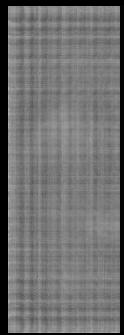


Unknown Non-ideal Wave Propagation in Real Display

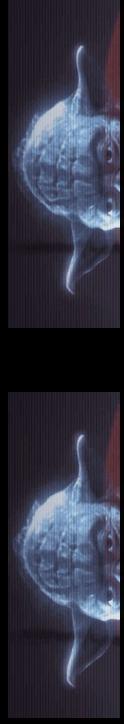


We propose phase retrieval using **learned hardware**

Phase Hologram



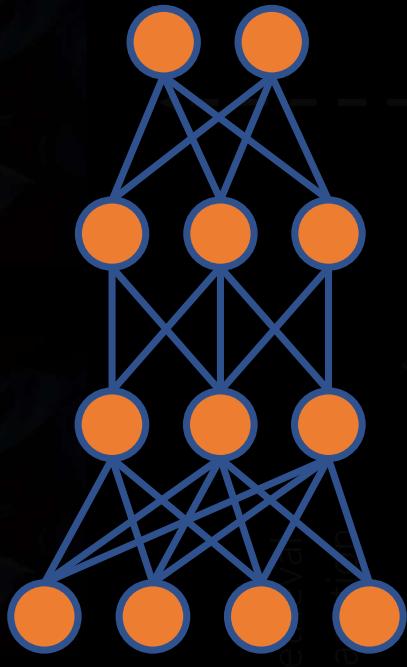
Target Predicted Real Capture



Real Hardware Holographic Display



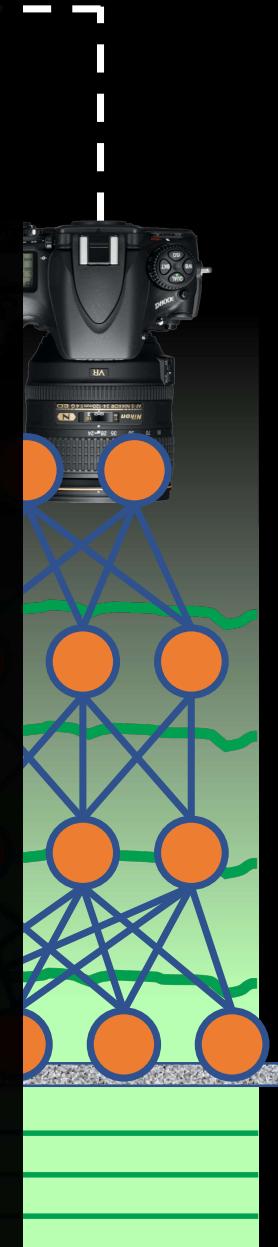
Learned Hardware Holographic Display



\approx



Learned Hardware Phase Retrieval
Non-Ideal Wave Propagation



Captured Real-time on Holographic Display

Previous State-of-the-art

Hardware-in-the-loop Phase Retrieval Method



Hardware-in-the-loop Phase Retrieval for Holographic Displays, SIGGRAPH Asia 2020