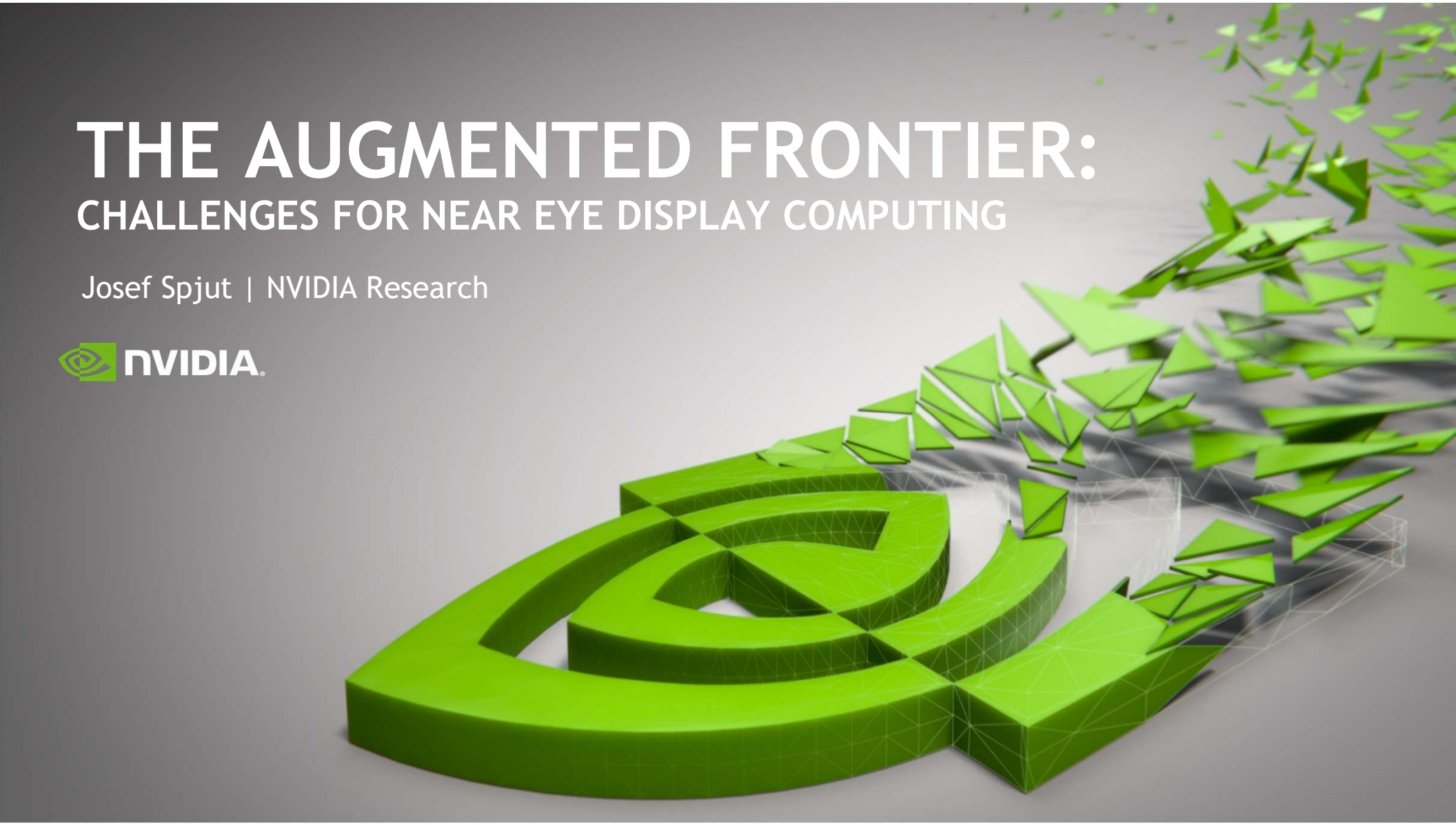
THE AUGMENTED FRONTIER:
CHALLENGES FOR NEAR EYE DISPLAY COMPUTING

Josef Spjut | NVIDIA Research

NVIDIA.



1. Augmented reality will be the new interface to computing for everyone
2. Augmented reality requires a new vertically-integrated graphics system

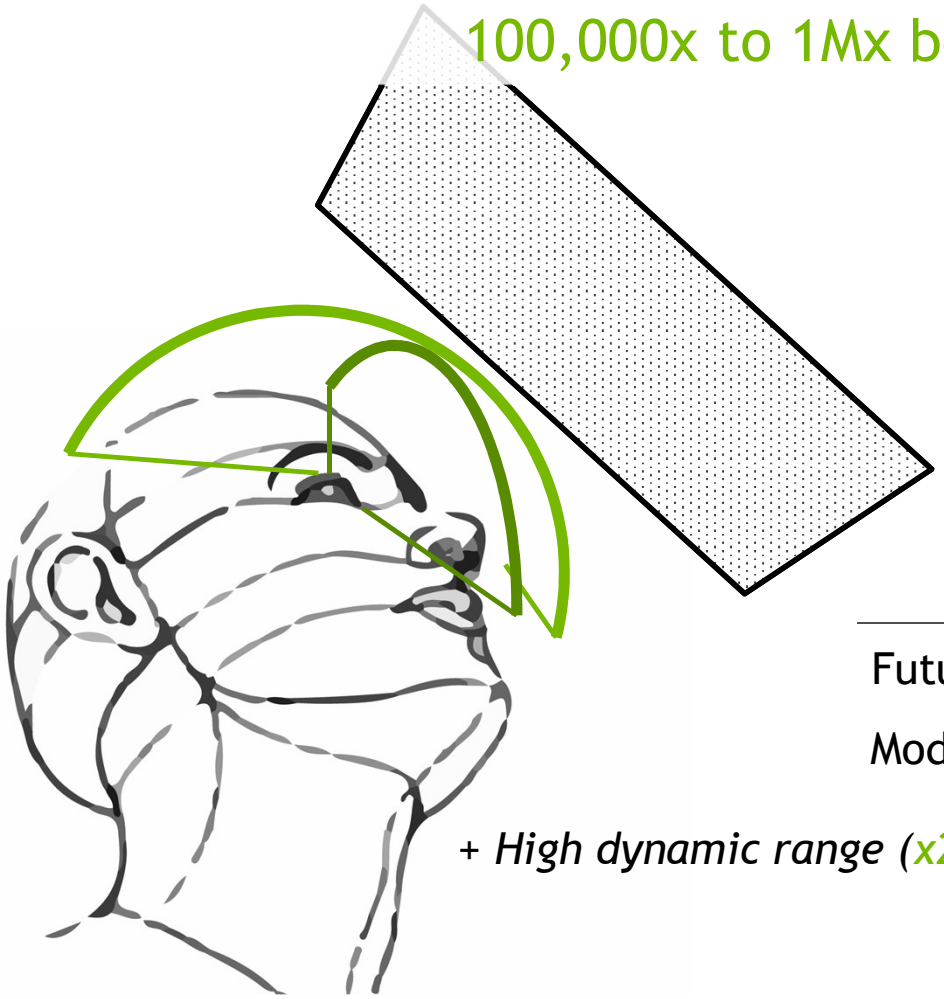
   sensors, algorithms, physics, rendering, AI, data structures, processors, optics, displays and haptics

NVIDIA AR/VR RESEARCH

Computational Displays	*Light field displays and varifocal optics*
Foveated Rendering	*Perceptually-guided rendering for massive throughput*
Ultra-Low Latency	*Hierarchical & binary rendering, beam racing, near-display warp*
Beyond Triangles	*Points, voxels, light fields, and text*
Path Tracing	*Extending ray tracing leadership to cinematic quality rendering*
Haptics	***New interaction modalities for near-eye-display***

LIMITS OF HUMAN PERCEPTION

100,000x to 1Mx beyond modern VR



220° Horizontal
x 135° Vertical

x (120 pixels/degree)^2

≈ 400,000,000 pixels
= 200 x 1080p TVs

x 240 Hz

Future VR = **100,000** Mpix/s

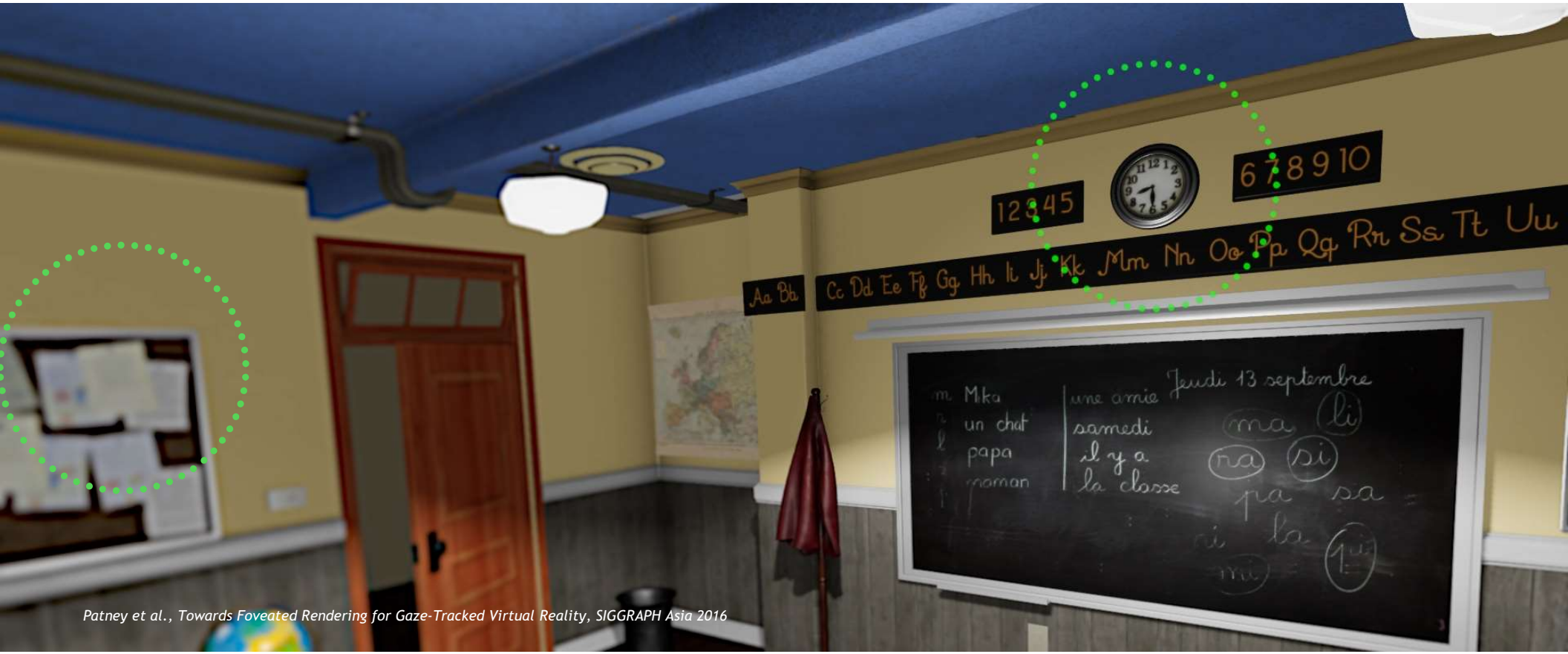
Modern VR = **450** Mpix/s

+ High dynamic range (x2), photorealistic dynamic lighting (x10,000), …

Head image from http://jeffsearle.blogspot.com/2015/09/drawing-head-from-different-angles.html

FOVEATED RENDERING

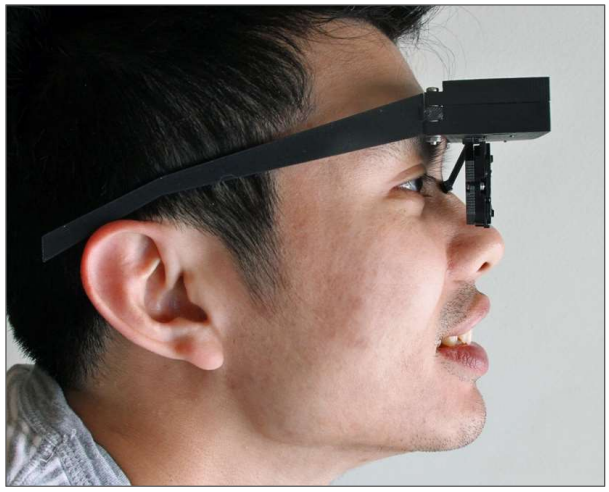
Our Approach: Perceptually Optimized



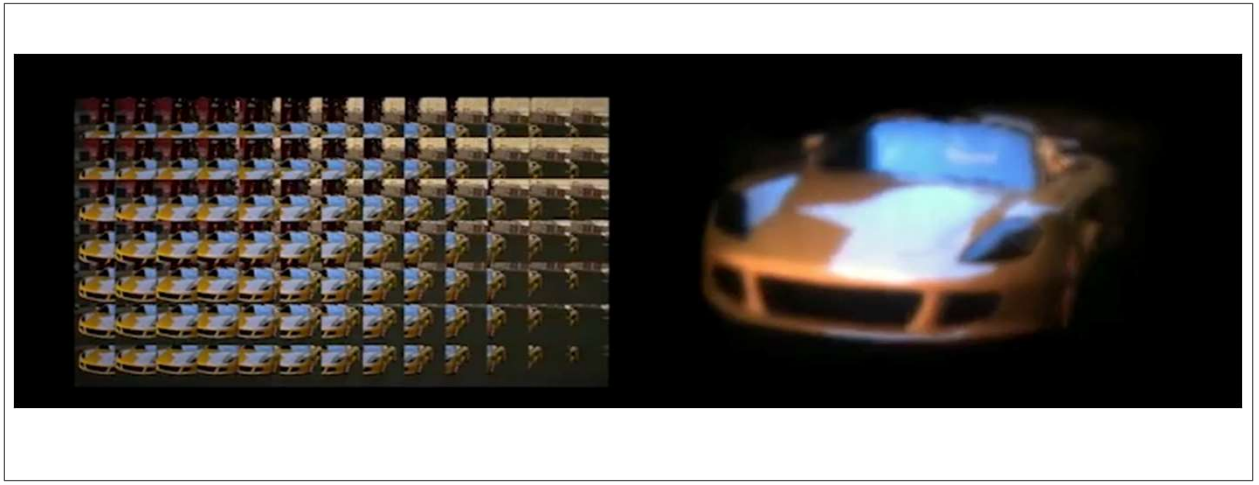
Patney et al., Towards Foveated Rendering for Gaze-Tracked Virtual Reality, SIGGRAPH Asia 2016

COMPUTATIONAL DISPLAYS

Light Field Display



Display Prototype



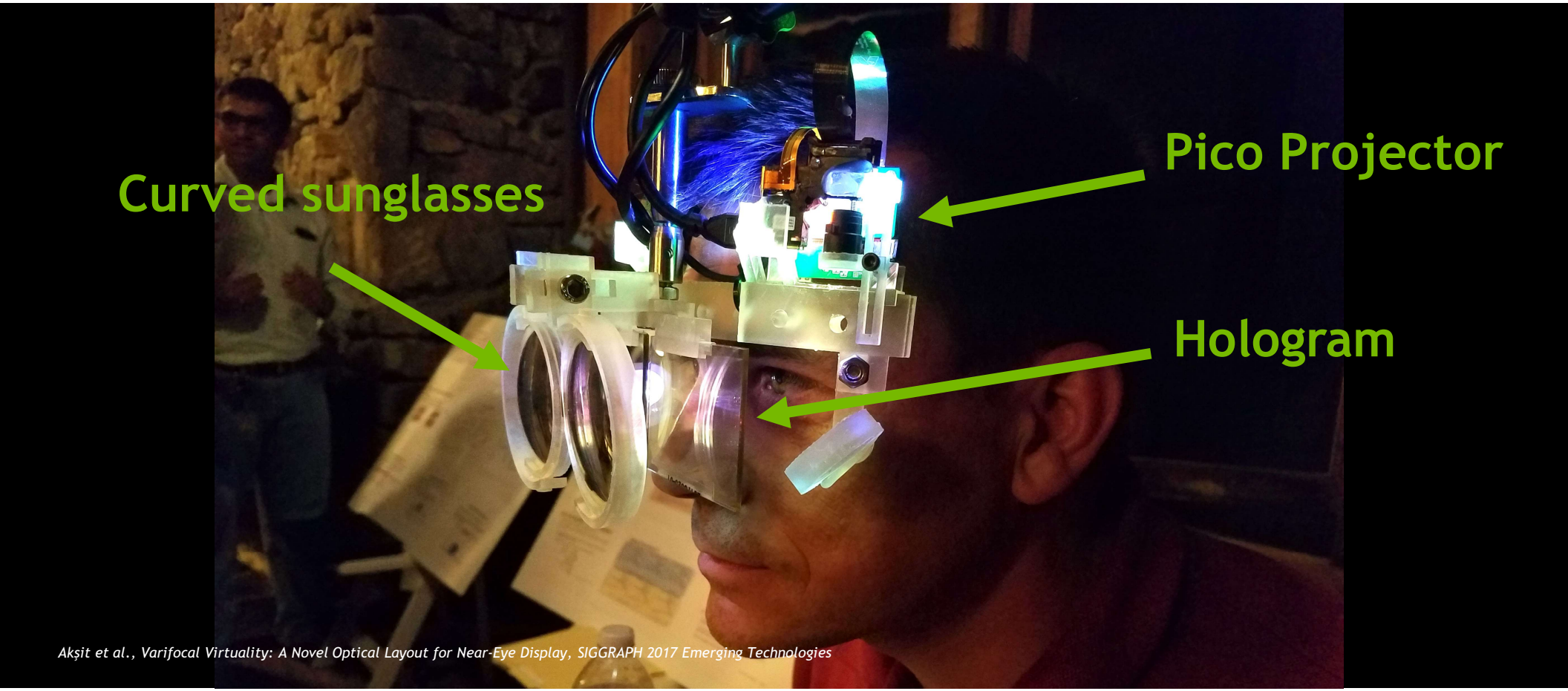
GPU Output

Observed Image

Lanman and Luebke, Near-Eye Light Field Displays, SIGGRAPH Asia 2013

COMPUTATIONAL DISPLAYS

Varifocal Optics



Akşit et al., Varifocal Virtuality: A Novel Optical Layout for Near-Eye Display, SIGGRAPH 2017 Emerging Technologies

COMPUTATIONAL DISPLAYS

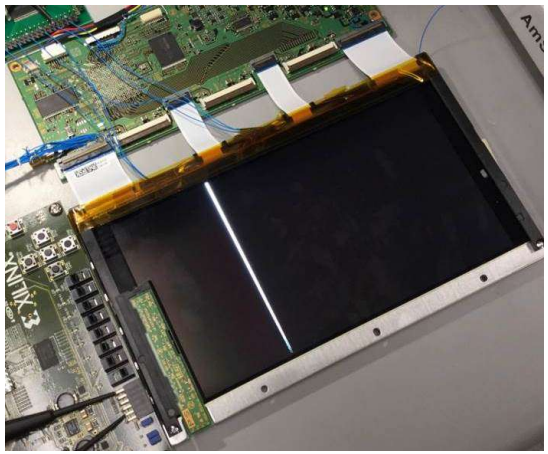
Varifocal Optics

Dunn et al, Wide field of view varifocal near-eye display using see-through deformable membrane mirrors, Proc. of IEEE VR 2017

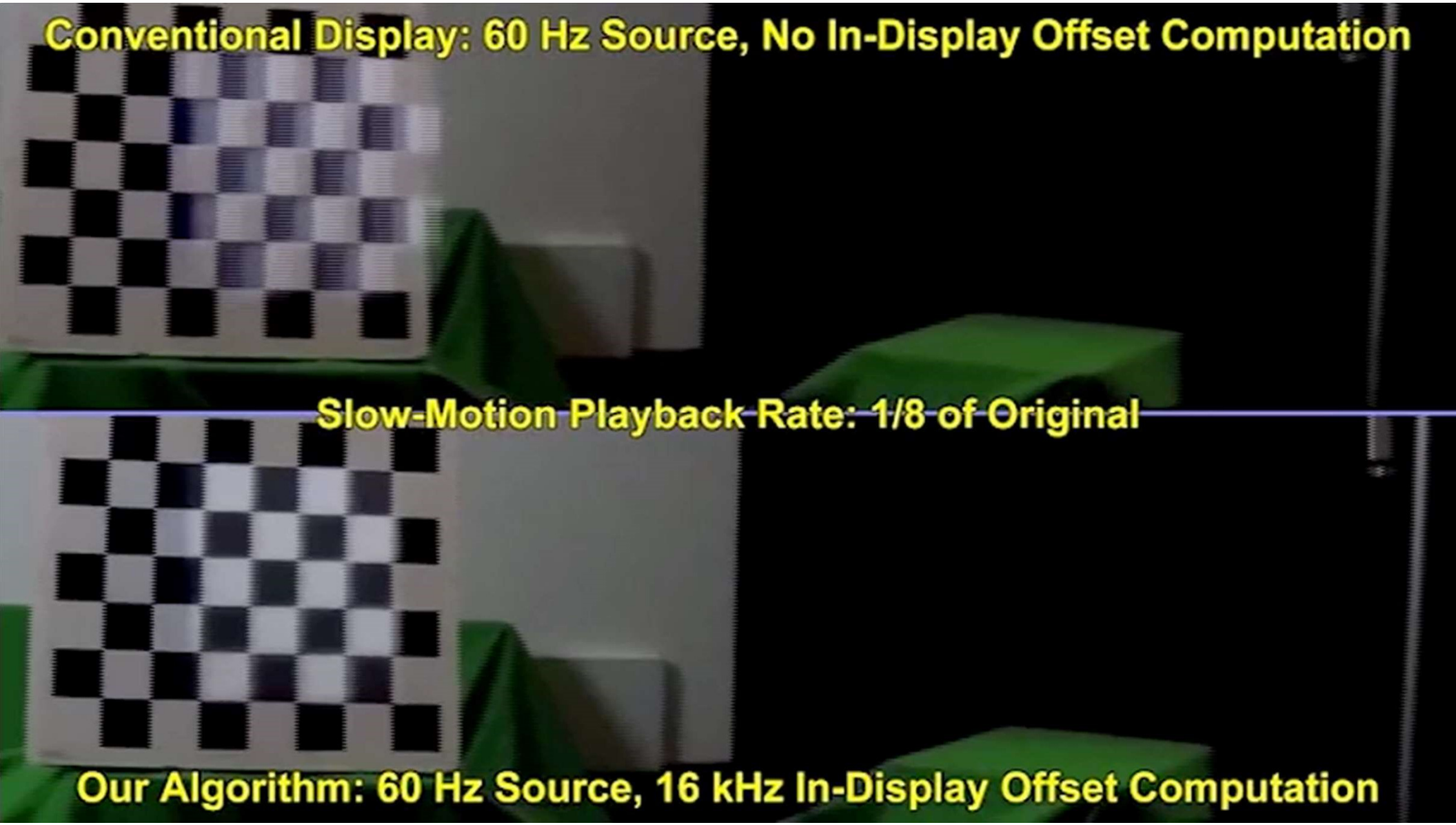
LATE STAGE TRACKING UPDATES

Insert tracking into the display modulation process to update position faster than frame rate

Trey Greer, Josef Spjut, David Luebke, Turner Whitted, “Hybrid Modulation for Near-Zero Display Latency,” SID Digest of Technical Papers, May 2016.

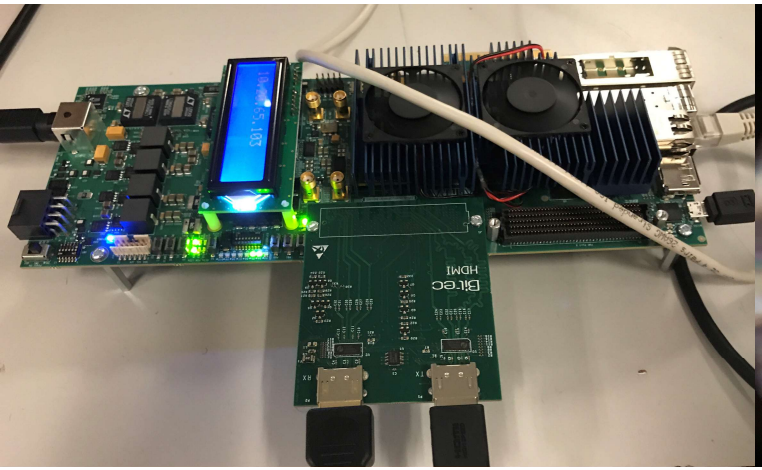


Peter Lincoln, Alex Blate, Montek Singh, Turner Whitted, Andrei State, Anselmo Lastra, and Henry Fuchs, “From Motion to Photons in 80 Microseconds: Towards Minimal Latency for Virtual and Augmented Reality,” IEEE Transactions on Visualization and Computer Graphics, April 2016.

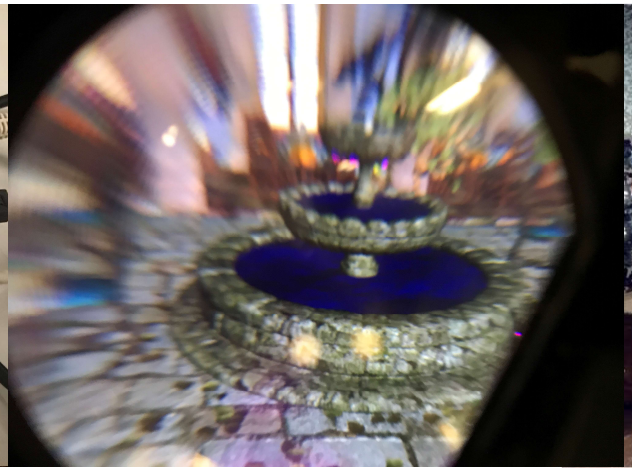

Conventional Display: 60 Hz Source, No In-Display Offset Computation
Slow-Motion Playback Rate: 1/8 of Original
Our Algorithm: 60 Hz Source, 16 kHz In-Display Offset Computation

LOW LATENCY

On-HMD Warping



Hardware Warping Prototype



Photographed in HMD

Warped Static Point Set

DENOISING PATH TRACING

Chaitanya et al., Interactive reconstruction of Monte Carlo image sequences using a recurrent denoising autoencoder, SIGGRAPH 2017
Schied et al., Spatiotemporal variance guided filtering: real-time reconstruction for path tracing, High Performance Graphics 2017
Mara et al., An efficient denoising algorithm for global illumination, High Performance Graphics 2017

AI GRAPHICS NVIDIA RESEARCH

AI Facial Animation

AI Denoising

AI Anti-Aliasing

AI Light Transport

KINESTHETIC HAPTICS

Active Interaction

Passive Interaction

Peele et al., Stretchable Transducers for Haptic Interactions in Virtual and Augmented Reality, GTC 2017
Shepherd et al., Stretchable Transducers for Kinesthetic Interactions in Virtual Reality, SIGGRAPH Emerging Technologies 2017
Mac Murray et al., Variable Shape and Variable Stiffness Controller for Tactile Virtual Interactions, Under Review 2018

1. Augmented reality will be the new interface to computing for everyone
2. Pascal architecture upgrades the gaming system to modern VR/AR

   GPU warping, lens matched shading, multiprojection, stereo projection, variable resolution

3. NVIDIA is innovating for a revolutionary new future NED system

   computational displays, varifocal optics, foveated & cloud rendering, light fields, binary frames, on-display warping, beam racing, haptics, path tracing, denoising


http://research.nvidia.com