

Energy-Efficient Adaptive 3D Sensing

Brevin Tilmon¹, Zhanghao Sun², Sanjeev Koppal¹,
Yicheng Wu³, Georgios Evangelidis³, Ramzi Zahreddine³,
Gurunandan Krishnan³, Sizhuo Ma^{3*}, and Jian Wang^{3*}

University of Florida¹



Stanford University²



Snap Inc³

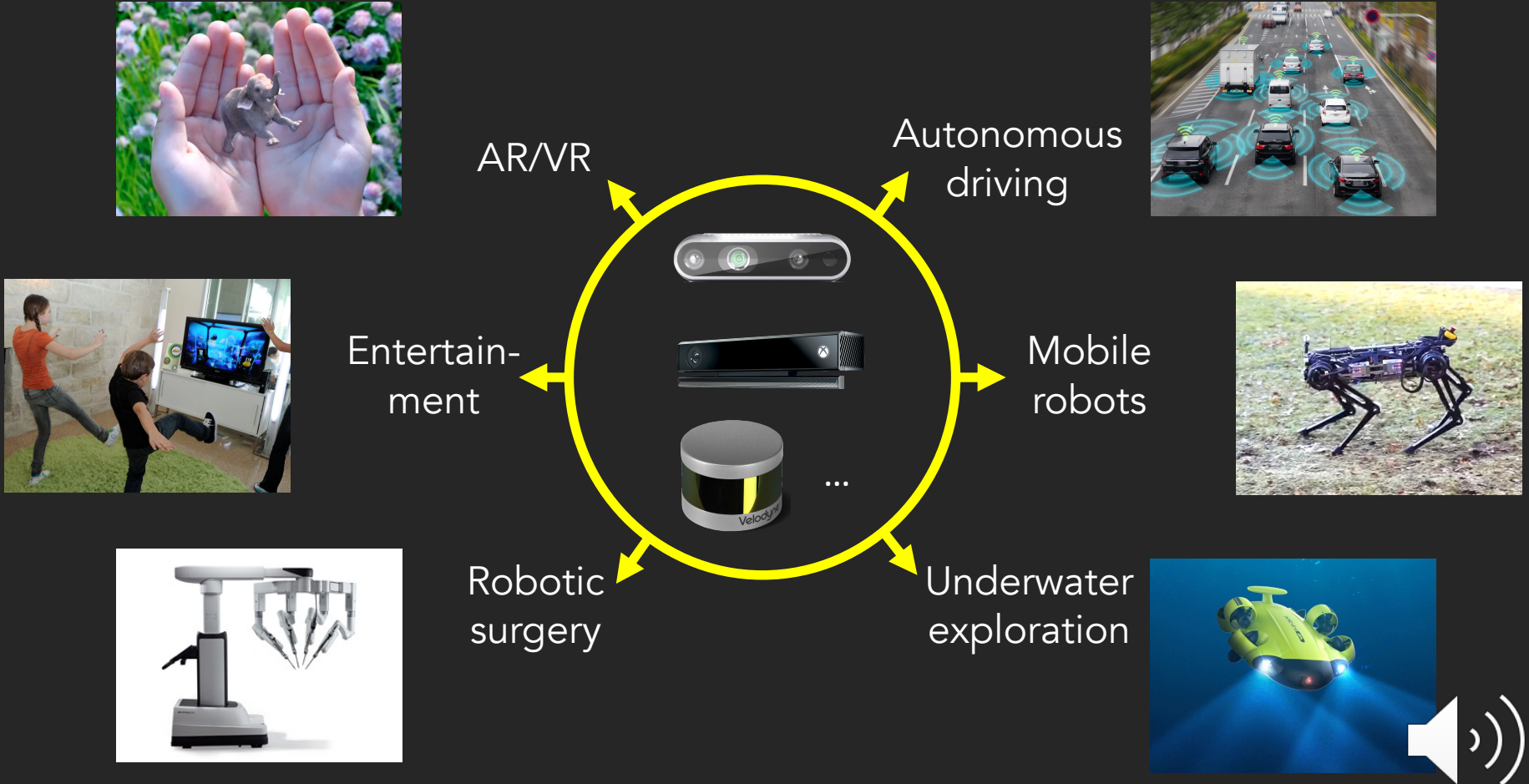


TUE-PM-087

Project Website: <https://btilmon.github.io/e3d.html>

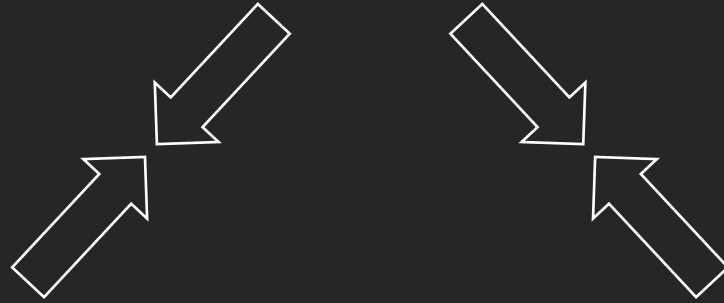
Code: <https://github.com/btilmon/hoLoCu>

Active 3D Sensing



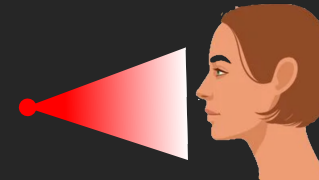
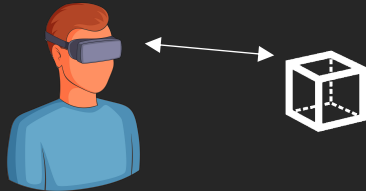
Challenges

Low power 



Long sensible distance

Short eye-safety distance



Key Observation



N I A N T I C

Only depth of an ROI is needed for many applications (dubbed as foveated 3d vision), e.g., AR character rendering



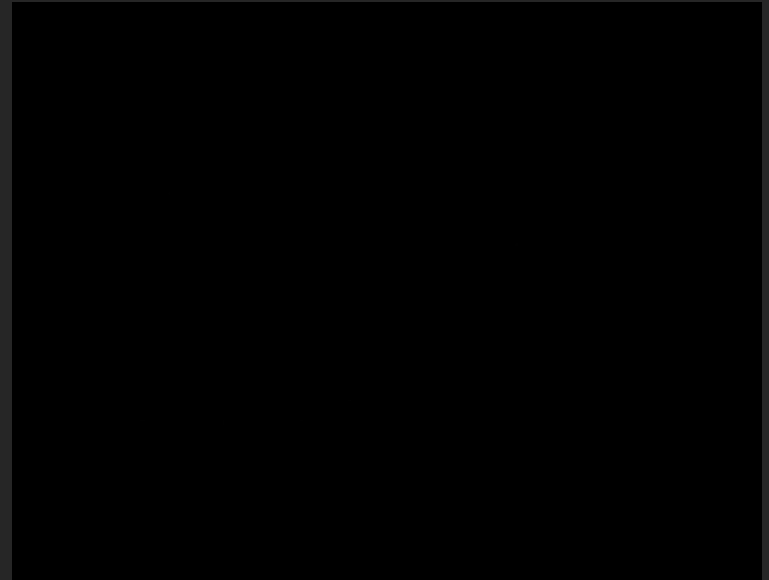
Key Observation



Only the textureless regions need pattern



Key Observation






Only the textureless regions need pattern

Only the regions with high uncertainty from previous frames for depth fusion



Proposed Method



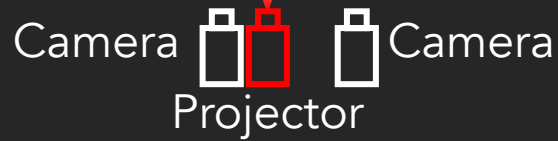
Camera    Camera
Projector



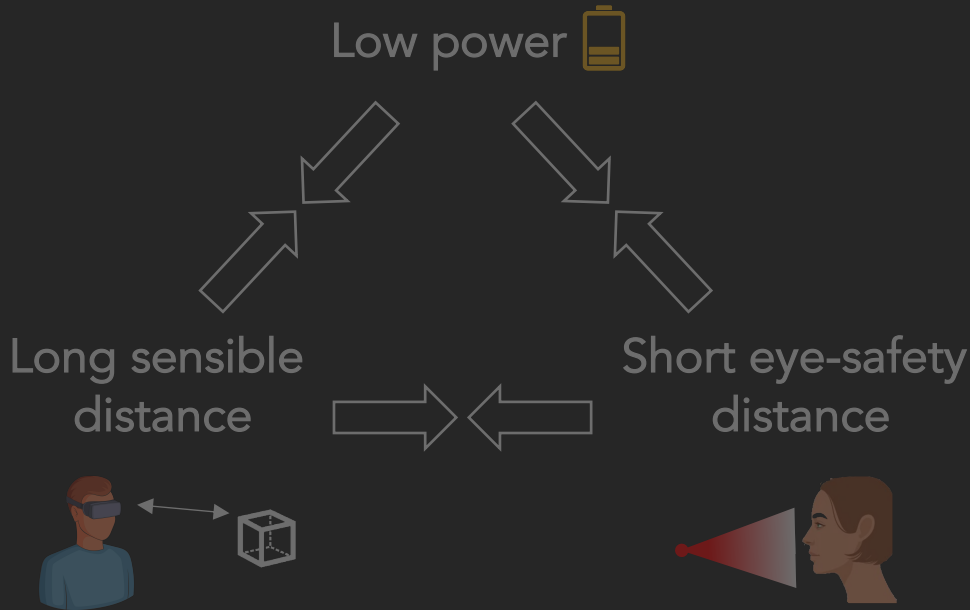
Proposed Method



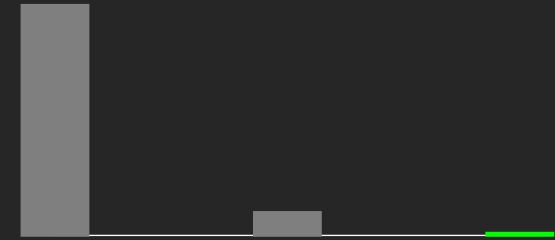
The optical power is redistributed to the ROI.



Proposed Method



When distance is the same
Required power (↓ is better)



Eye-safety distance (↓ is better)

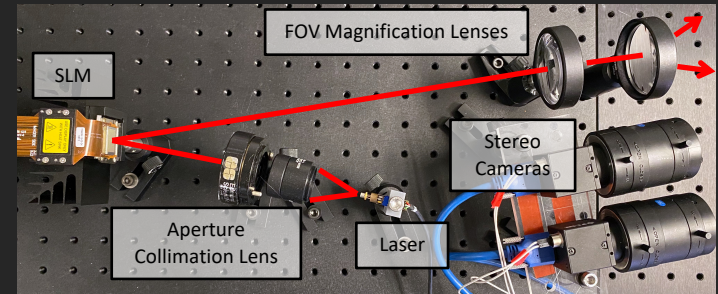
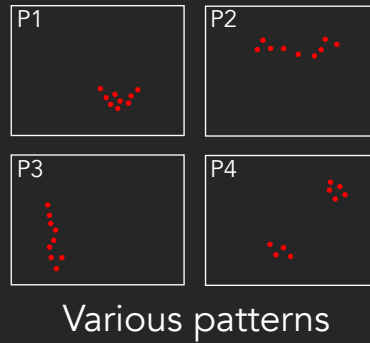
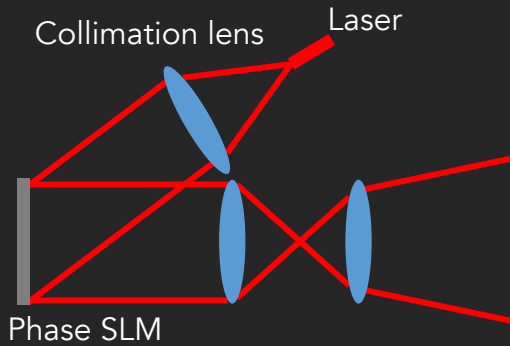


Full pattern Line scanning Adaptive pattern
(prev. SOTA) (ours)

* See paper for the derivations 

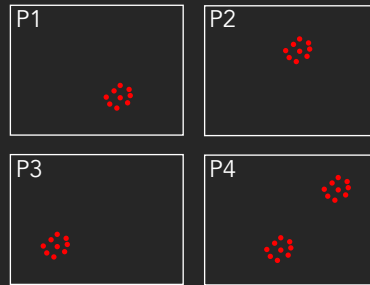
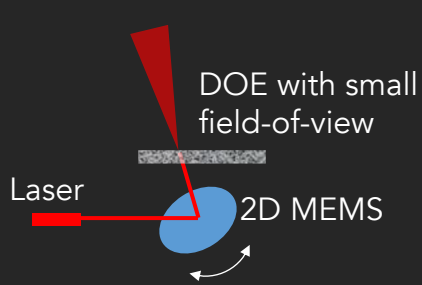
Implementation Methods

Phase SLM-based implementation

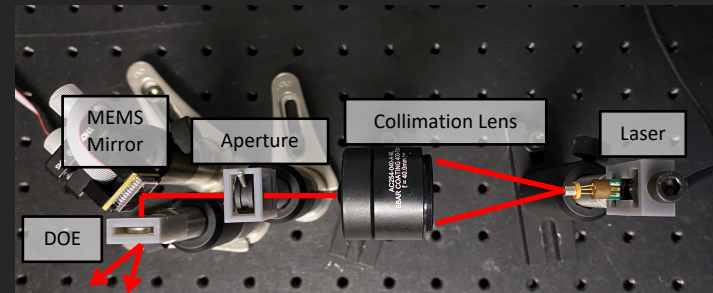


Implementation Methods

MEMS + DOE-based implementation

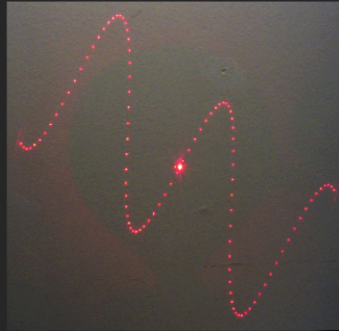


Various patterns

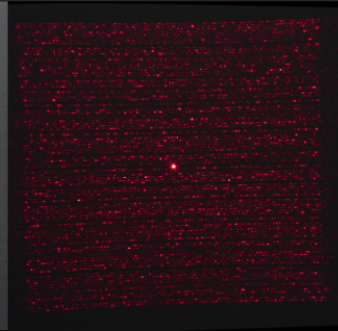


Results: Emulating 3D Sensors on Phase SLM

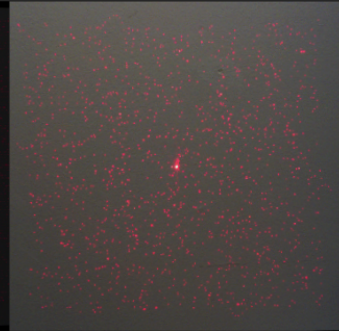
Adaptive



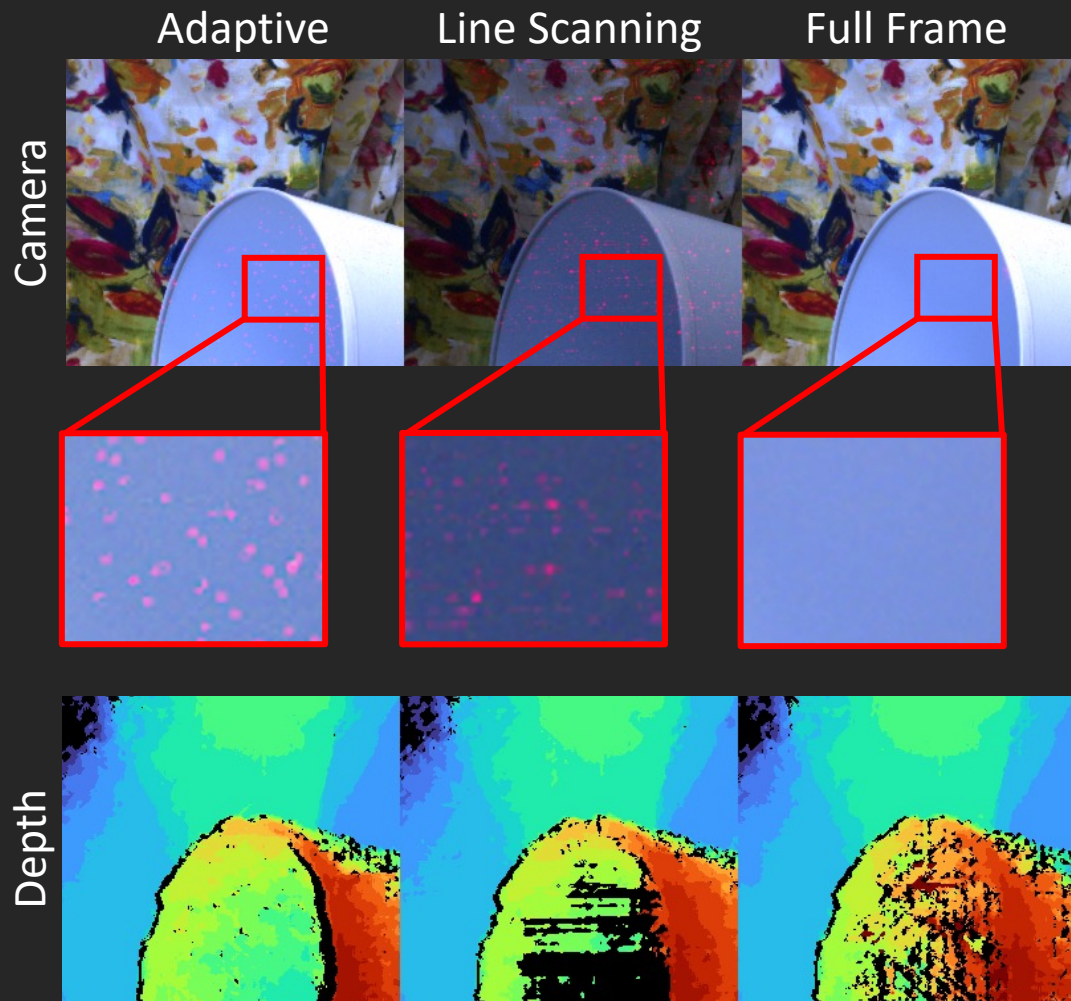
Line Scanning



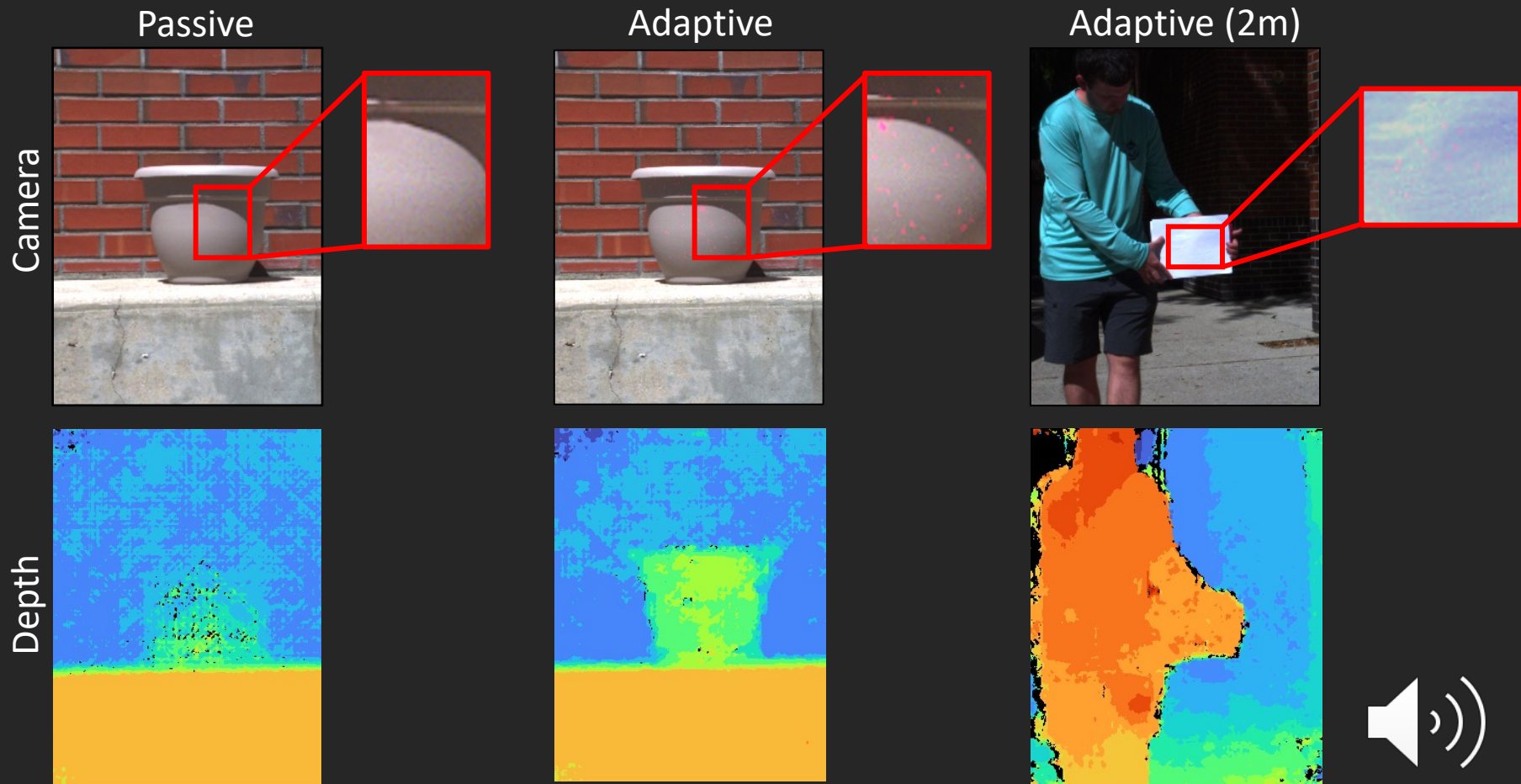
Full Frame



Results: Comparison with Existing Methods

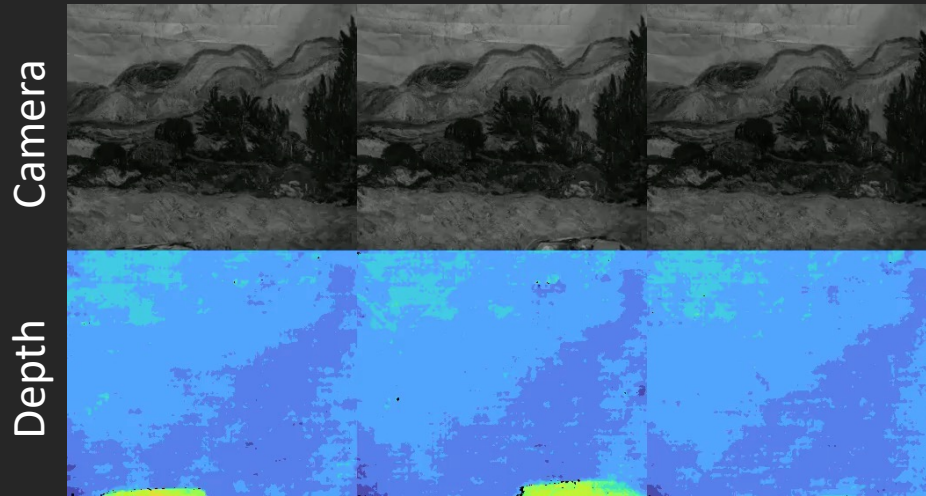


Results: Adaptive 3D Sensing in Bright Sunlight



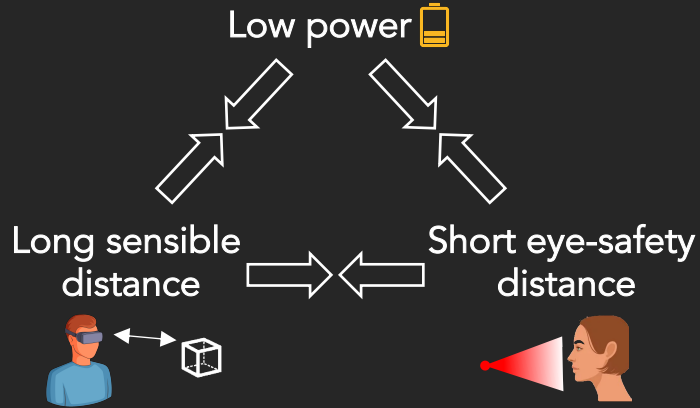
Results: Real Time Adaptive 3D Sensing

Laser Off (Active Stereo)

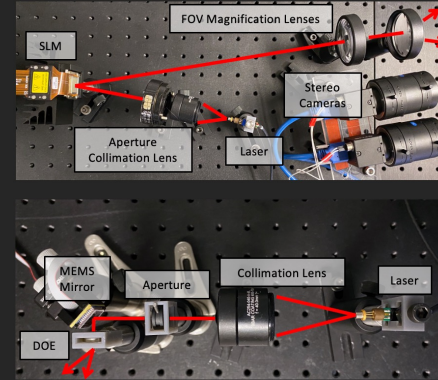


Summary

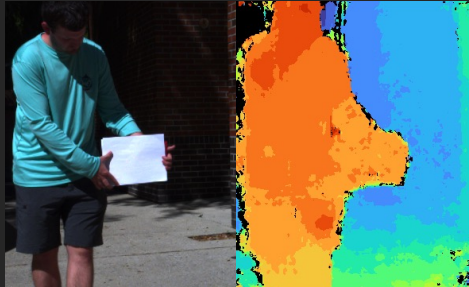
Analysis



Hardware Prototypes



Experiments



Applications

