

Non-Line-of-Sight Imaging with Single Photon Cameras Talha Sultan¹, Eric Brandt², Khadijeh Masumnia-Bisheh³, Andreas Velten^{1,3}

NIS

Poster # 7



- ✓ Non-Line-of-Sight (NLOS) imaging aims to help people "see around corners". [1]
- ✓ Reconstructs 3D images (x) from transient measurements ($y = f(x) + \epsilon$)
- ✓ Practical Applications of NLOS Imaging:



Part I: Hardware Set Up

✓ A pulsed laser and a fast transient detector, such as a Single Photon Avalanche Diode (SPAD) [4], enable us to send and detect centimeter-scale light echoes at a Relay Wall that is in the observer's line of sight.



✓ "Smart computational algorithms" are developed to recover 3D images of the hidden scene from "transient measurements".





"Picture" of hidden scene



3D Reconstruction

"Reconstruction" of hidden scene - Front View



Back Proiection Method

¹Department of Electrical and Computer Engineering, University of Wisconsin – Madison, Madison, WI, USA. ²Department of Computer Science, University of Wisconsin – Madison, Madison, WI, USA. ³Department of Biostatistics and Medical Informatics, University of Wisconsin – Madison, Madison, WI, USA.

Part II: Reconstruction Algorithms / Phasor Field Method

✓ The problem of non-line-of-sight imaging can be formulated as a line-of-sight imaging problem using the phasor field approach where a virtual wave field propagates mathematically through the scene. [5]



State of the Art, Fast 3D-reconstructions algorithms works for arbitrary illumination ~ and detection patterns on a relay wall [6], [7]



Future Directions

- ✓ Hyperspectral NLOS imaging techniques using a tunable laser.
- ~ Reconstruct images around multiple corners

References & Related Research

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0.1109/JSEN 2022.3193111.

Contact Information

Let's stay connected :)

Talha Sultan: tsultan@wisc.edu Andreas Velten: velten@wisc.edu Lab: https://biostat.wisc.edu/~compoptics/



Real-Time NLOS

NLOS Results Developed with Our Lab

I. Live Video Reconstructions

✓ Multi-pixel SPAD arrays, fast data acquisition, and reconstruction algorithms tuned for GPU and multi-threaded CPU allow live video reconstruction of 3D-volumes with a standalone high end desktop PC [8].



II. Non-Planar Geometries

✓ Reconstruction algorithms can be tuned to reconstruct hidden scenes from non-planar (and even non-stationary) relay walls [9].





III. SPAD Array



- Using an array of SPAD detectors [10] that simultaneously capture higher order bounce reflected light results in reconstructions with higher SNR for a given exposure time.
- Alternatively, the SNR achieved by a single pixel can be duplicated with a much shorter exposure time when multiple detectors observe the scene simultaneously.
- The same exposure time was used for all 3 images below

Single Pixel











IV. General Surface Reflectance

✓ Phasor Field method is able to reconstruct diffuse and specular surfaces, requiring no prior assumptions on surface reflectance [11].



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