

Integration and experimental validation of a SPAD array in an NLOS imaging setup

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Abstract: Experimental NLOS measurements with a 32×32 SPAD array are compared with calibrated single pixel data under identical conditions, validating performance gains, revealing wall mapping distortions, and motivating dedicated calibration for robust parallel hidden scene imaging

Non-line-of-sight (NLOS) imaging enables the reconstruction of hidden scenes by exploiting multiply scattered light collected from a visible relay surface. Single-pixel SPAD-based systems offer high flexibility and accurate calibration, but they require sequential scanning. SPAD array cameras, by contrast, promise parallel acquisition and greater operational robustness, while introducing new integration and calibration challenges.

In this work, we present a gap analysis between these two architectures by combining experimental and synthetic datasets to estimate, under comparable conditions, the expected benefit of SPAD arrays over single-pixel systems and to identify the main limiting factors in real scenarios, especially as target reflectivity changes.

Following the procurement of a 32×32 SPAD array, we report NLOS measurements of a diffusive target and, under the same experimental conditions, reference measurements acquired with a calibrated single-pixel SPAD system. Processing both datasets with the same reconstruction pipeline allows us to quantify the advantages and limitations of the transition from sequential to parallel acquisition.

The results confirm an improvement in measurement performance with the SPAD array, in agreement with the expectations derived from simulation. At the same time, reconstruction distortions emerge when the relay wall is observed at a generic angle, highlighting the need for dedicated wall calibration to correct the mapping between detector pixels and wall points [1].

Overall, this work provides an experimental validation of the upgrade from a single-pixel detector to a SPAD array and establishes the basis for the integration of more robust calibration procedures and for NLOS demonstrations under more general operating conditions.

Reference

[1] R. Romanelli, U. Zanforlin, E. Mauri, et al., “Effect of relay surface calibration on reconstruction capabilities of SPAD array-based non-line-of-sight imaging systems,” in *Quantum Technologies for Defence and Security II, Proc. SPIE 13676*, 136760D (2025).