Non-Line-of-Sight Imaging with Single Photon Cameras

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Abstract:

Non-line-of-Sight (NLOS) Imaging utilizes indirect reflections of light to “see around corners”, and has applications in diverse areas such as military, surgery, disaster response, manufacturing, monitoring of equipment in hostile environments, and autonomous navigation. The most promising methods utilize time-gated illumination and time-of-flight detectors that can capture light transport at picosecond resolution, generating high-quality 3D reconstructions of the hidden scene. Of the many sensor technologies available, single-photon avalanche diodes (SPADs) show the most promise due to their single-photon sensitivity, high timing resolution, and commercial and manufacturing scalability. However, NLOS imaging is a photon-starved application and images reconstructed using single-pixel SPAD sensors suffer from low SNR. To generate high quality 3D NLOS reconstructions, long exposure times are required which limit the ability to deploy NLOS systems “in the wild ".

One possible solution to avoid long exposure times is to exploit an array of single-pixel SPADs to capture more photons in the same amount of time. By pairing an array structure with adjustments to the underlying capture and reconstruction algorithms, practical uses of such an imaging system become much more viable. In this work, we introduce a 16x16 pixel SPAD array and successfully utilize it as a NLOS imaging system. We demonstrate how increasing the number of pixels can be used to improve SNR, or alternatively, reduce exposure time thus increasing the feasibility of NLOS systems for real world scenarios.