Sparsity and Rank Constraints in Inverse Light Transport Problems: Looking Around Corners, Exploring Holograms and Analyzing Fast Events

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Abstract

A traditional camera captures a 2D image, but more sophisticated devices can capture a higher dimensional signal. The devices include 4D lightfield cameras, camera arrays, reflectance field captures, light stage domes, multispectral and time of flight cameras. Compared to 2D images, these higher dimensional signals exhibit more sparsity, present unusual rank constraints and provide new opportunities for coding and decoding for scene understanding.
We will study these concepts in the context of three examples (a) Looking Around Corners, (b) Exploring Holograms and (c) Analyzing Fast Events.

(a) Can we look around corners beyond the line of sight? We can exploit the finite speed of light to improve image capture and scene understanding. New theoretical analysis coupled with emerging ultra-high-speed imaging techniques can lead to a new source of computational visual perception. We are developing the theoretical foundation for sensing and reasoning using Femto-photography and transient light transport, and experimenting with scenarios in which transient reasoning exposes scene properties that are beyond the reach of traditional computer vision. (joint work with a large team, pl see http://raskar.info/femto)

(b) Holograms and diffractive elements can now be (approximately) described with an 'augmented light field' that involves only rays. This brings such elements into the realm of computer vision, linear algebra and optimization techniques. It turns of that these signals have a strong rank-constraint that can be exploited to capture multi-view imagery, to create optical configurations for computational photography and to build novel 3D displays. (joint work with Roarke Horstmeyer, Doug Lanman, Matt Hirsch, Se Baek Oh, George Barbastathis)

(c) High speed events are difficult to analyze due to the bandwidth and SNR constraints. But these image streams can be represented with sparse coefficients in the appropriate transformed domain. Using ideas in compressive sensing, one can build cameras and corresponding reconstruction algorithms to capture high speed events (joint work with Ashok Veeraraghavan, Dikpal Reddy)

Syllabus: Camera Culture, Computational Camera and Photography, Inverse Problems