Compressive Imaging

Conventional Imaging: sensing by sampling

\[ \text{Object} \xrightarrow{\chi} \text{Sample} \xrightarrow{N} \text{Compress} \xrightarrow{K} \text{Transmit/store} \]

- Step 1: sample data
- Step 2: compress data

\[ N \gg K \]

\[ \text{Receive} \xrightarrow{K} \text{Decompress} \xrightarrow{\hat{\chi}} \text{Image} \]

Compressive Sampling: Directly acquire a compressed image

\[ \text{Object} \xrightarrow{\chi} \text{Compressive Sampling} \xrightarrow{M} \text{Transmit/store} \]

\[ K < M \ll N \]

\[ \text{Receive} \xrightarrow{M} \text{Reconstruct} \xrightarrow{\hat{\chi}} \text{Image} \]

Compressive Imaging

First Demonstration: Rice table-top system
D.Takhar et. al. “A New Compressive Imaging Camera Architecture using Optical-Domain Compression” (Proc. of Computational Imaging IV at SPIE Electronic Imaging, San Jose, CA, Jan. 2006)

Visible-Light Demo System
• Physically compact
• Straight-forward Translation to IR operation

Can we make a compact version?

Collaboration with Mark Neifeld, Jun Ke & Pawan Baheti @ UAZ & Peter Illinykh & Pavel Shekhtmeyster @ PSI Lab
CI Demonstration Setup

Projected object scene

Optical Layout

- Fold mirror
- Relay lens
- Spherical mirror
- Detector planes
- Eight-reflection lens
- Right angle prism
- TI DLP

Cut Eight-Reflection lens

Cut & assembled optics

Apogen DMD board
System PSF:

~ 5 pixel spread caused by edge scattering at the modified facets due to the short, suboptimal object conjugate:

Best Focus (design) = 2.5 m
Best Focus (measured) = 1.65 m
First Results: Linear Reconstruction

LMMSE estimation of Hadamard Features

Object: 64x64 (4096 data points)

38 measurements
1% of object’s dimensionality

200 measurements
5% of object’s dimensionality

Reconstructions performed by Jun Ke (UAZ)
Linear and Nonlinear reconstruction of Random Features:

- **Linear Reconstruction**
  - (1000 random masks)

- **Nonlinear Reconstruction**
  - (1000 random masks)

**Simulated Results**

**Experimental Results**

Random Features do not contain ordered spatial frequency information.

Object sparsity provides an advantage to nonlinear reconstruction.