Compressive Spectral-Video by Optimal 3D/4D-Sphere Packing

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OPTOLAB

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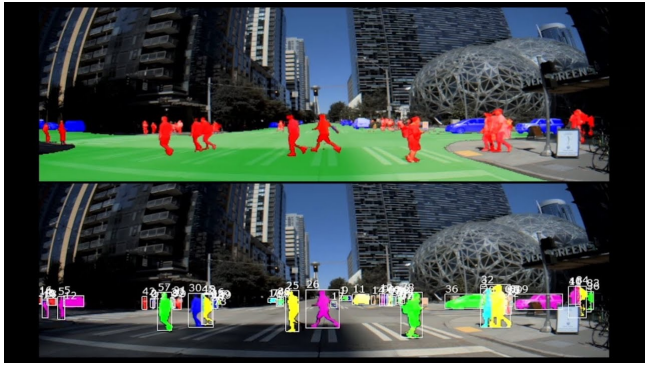
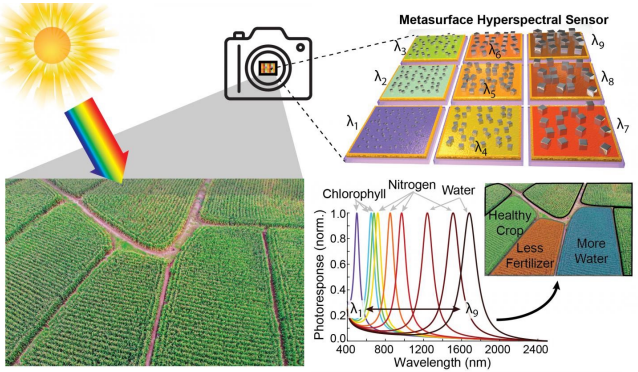
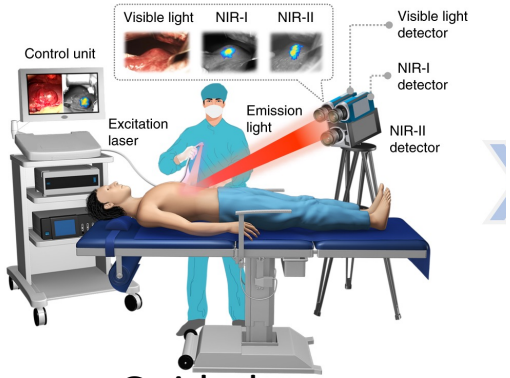
Applications of Spectral-Video



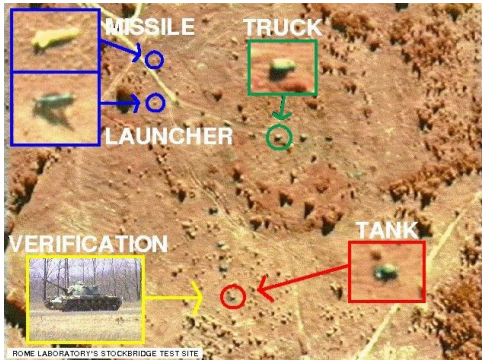
Self−driving car



Smart farming

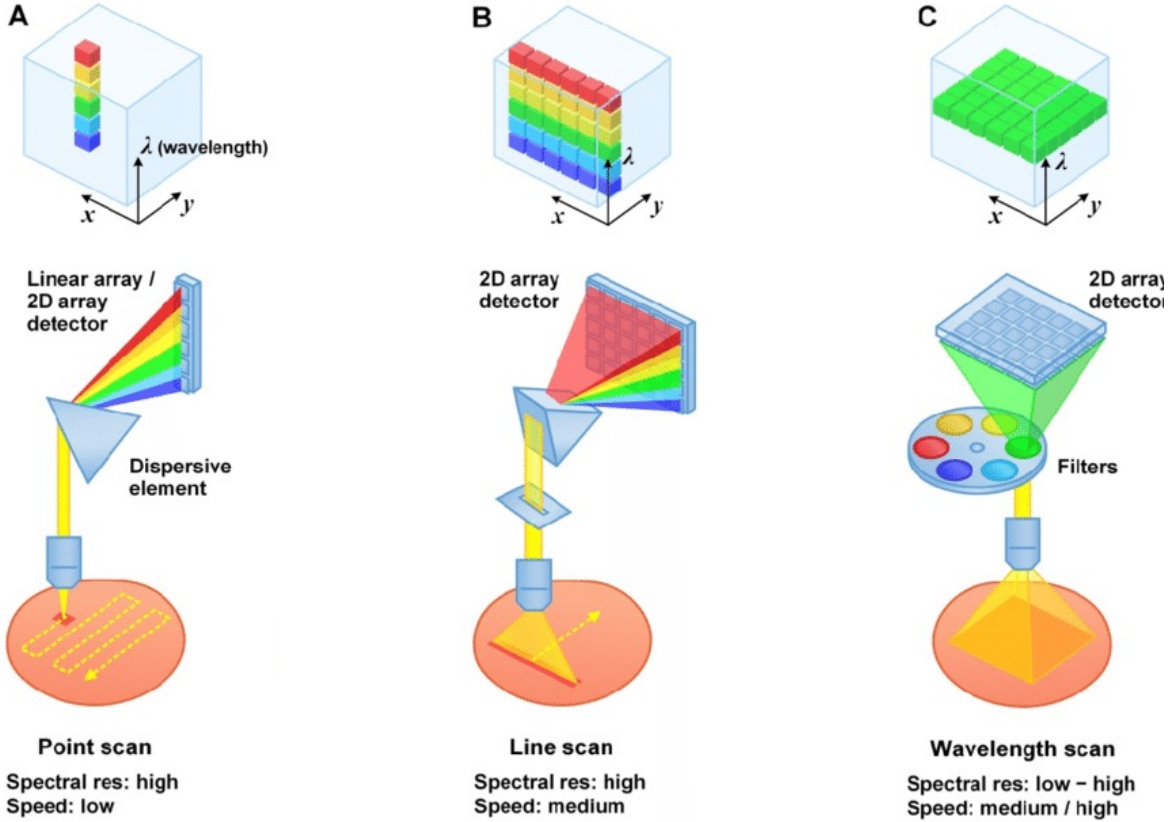


Guided surgery



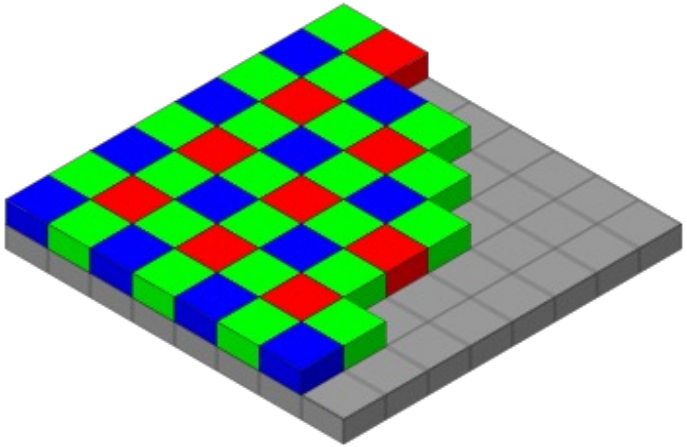
Camouflage detection

Traditional Approaches to Capture Spectral Images

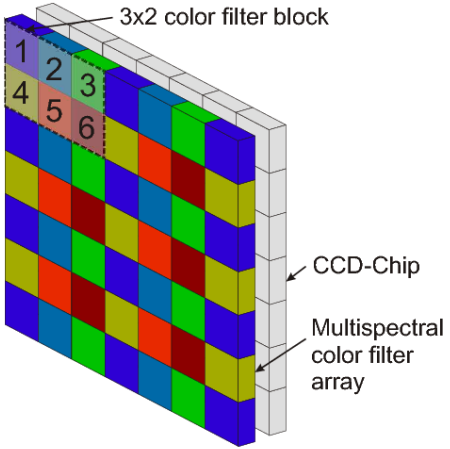


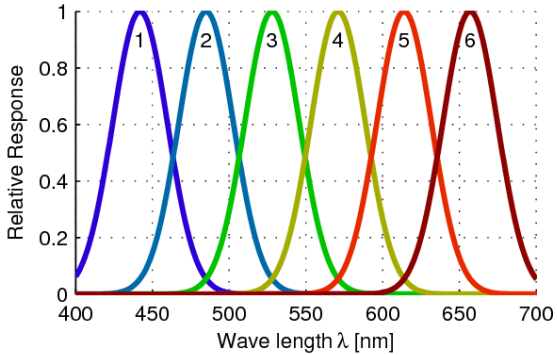
Multispectral Filter Arrays (MSFA)

Bayer Filter



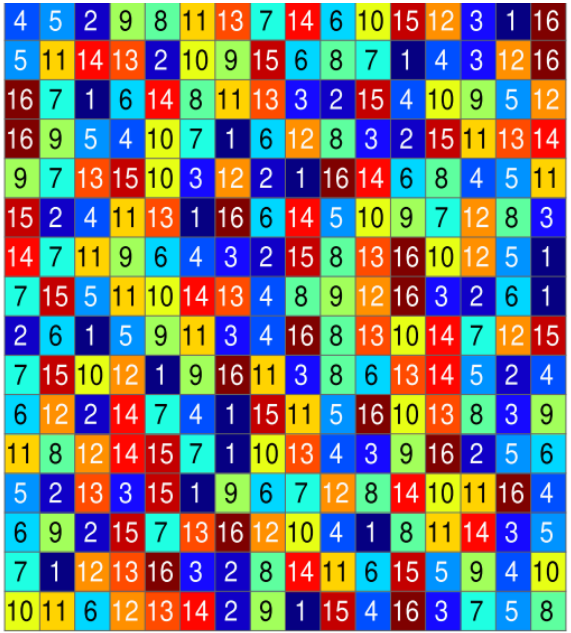
Multispectral Filter



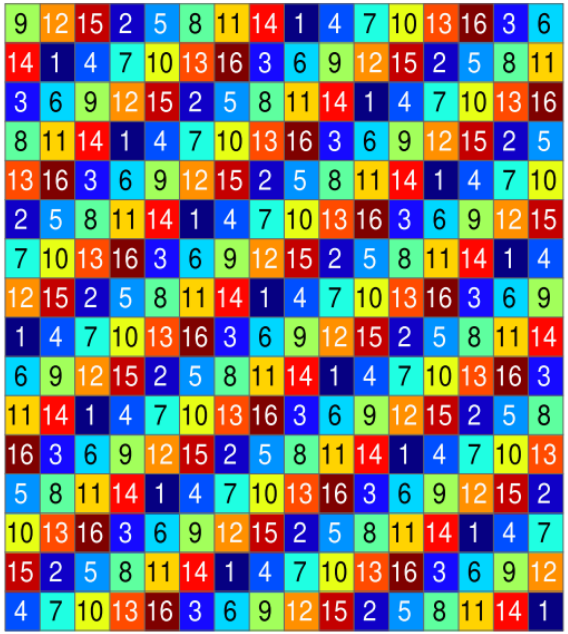


MSFA Design using Sphere Packing

Random



Designed



N. Diaz, A. Alvarado, P. Meza, F. Guzmán and E. Vera, ”Multispectral Filter Array Design by Optimal Sphere Packing,” in IEEE Transactions on Image Processing, vol. 32, 2023.

MSFA Design using Sphere Packing

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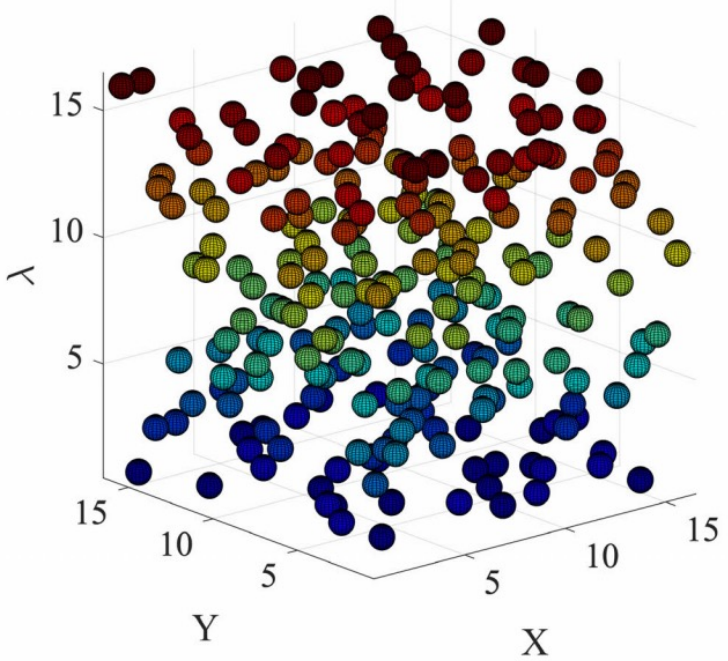

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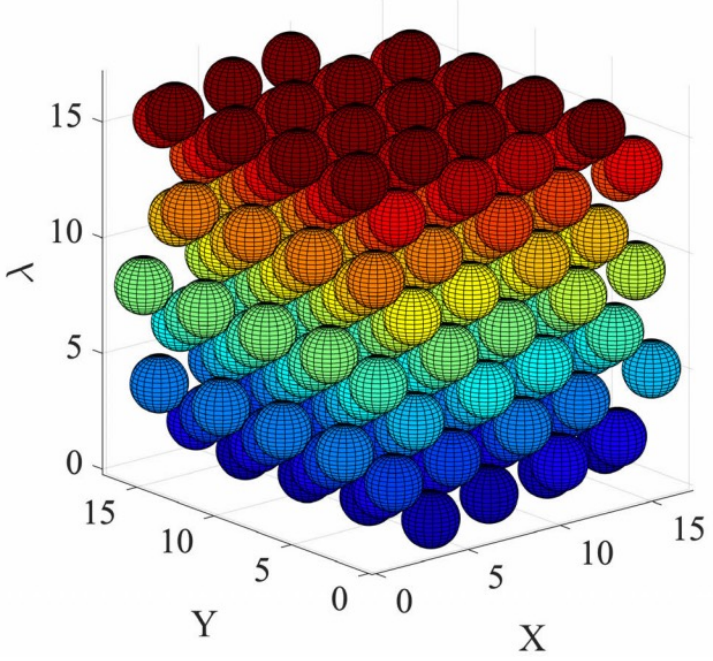

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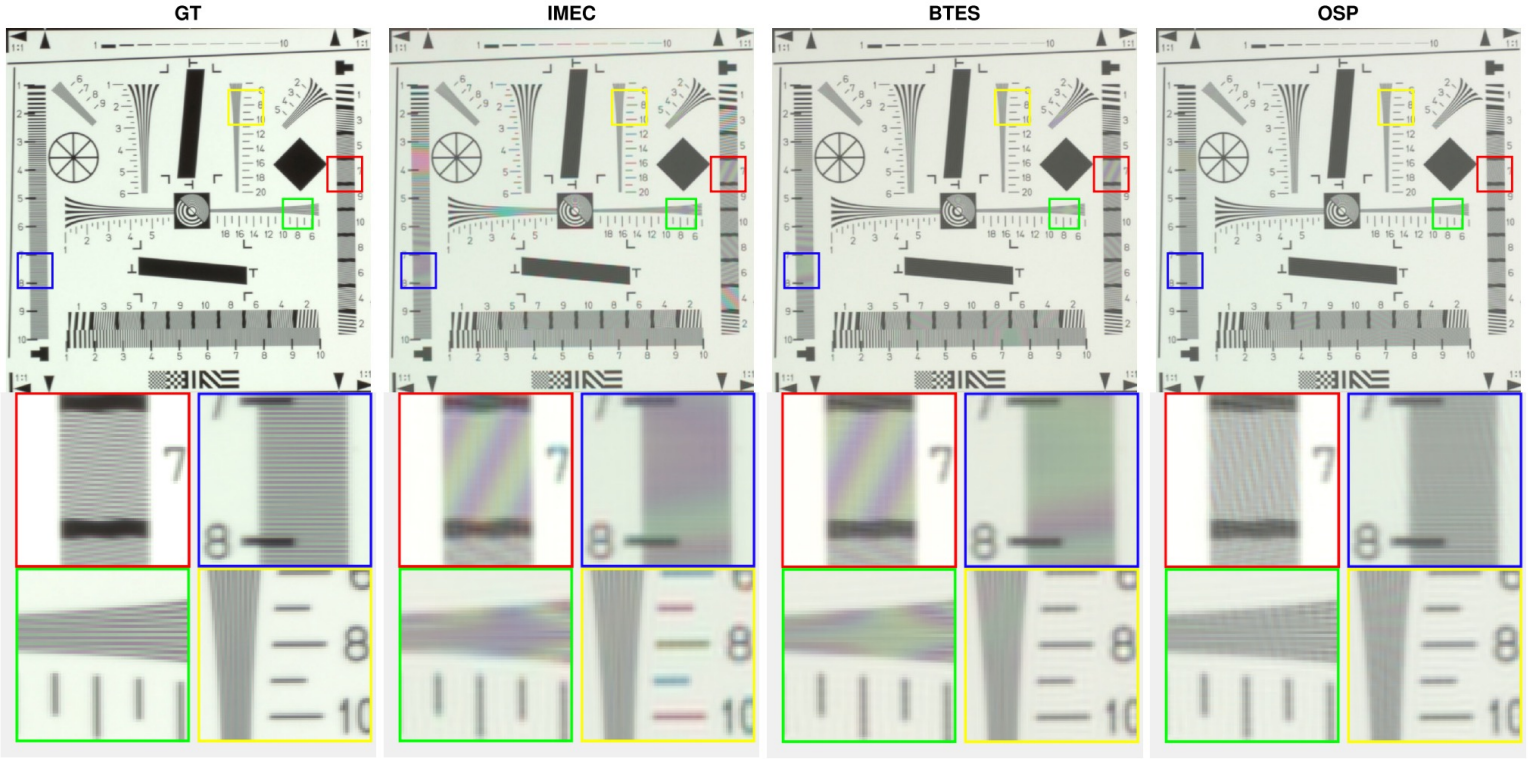
Reconstruction Results using MSFA



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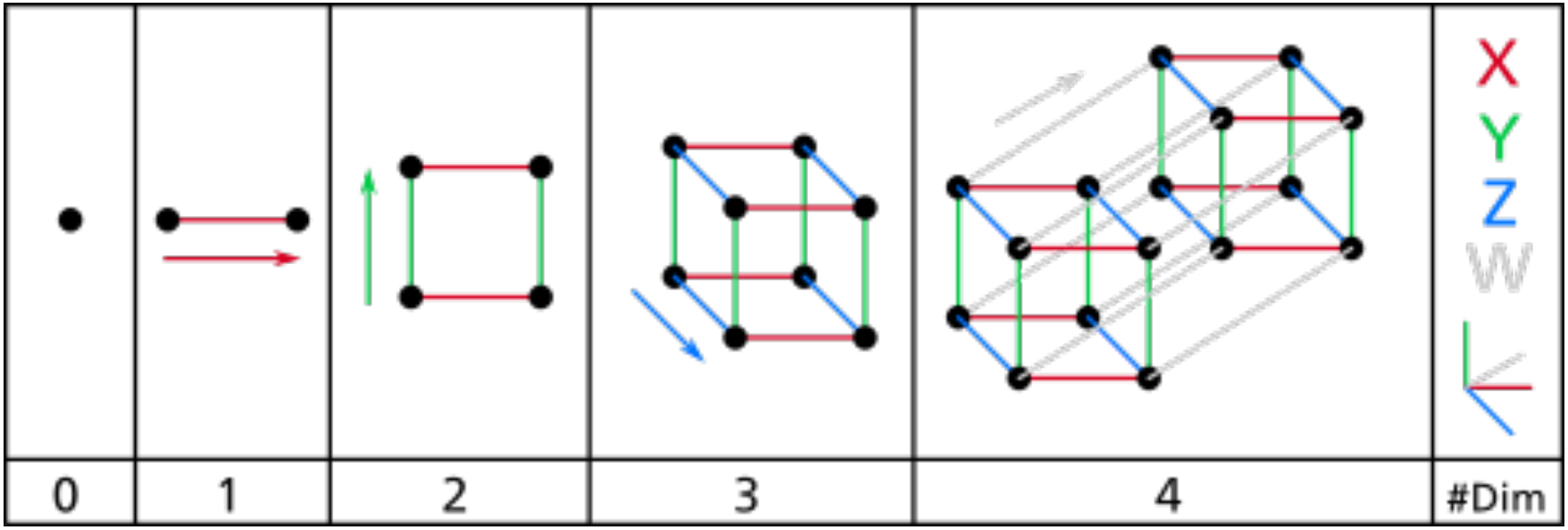
What is Sphere Packing?

The sphere packing problem asks for the densest packing of R^n with congruent balls. Equivalent to answer the question:

What is the largest fraction of R^n that can be covered by congruent balls with disjoint interiors?

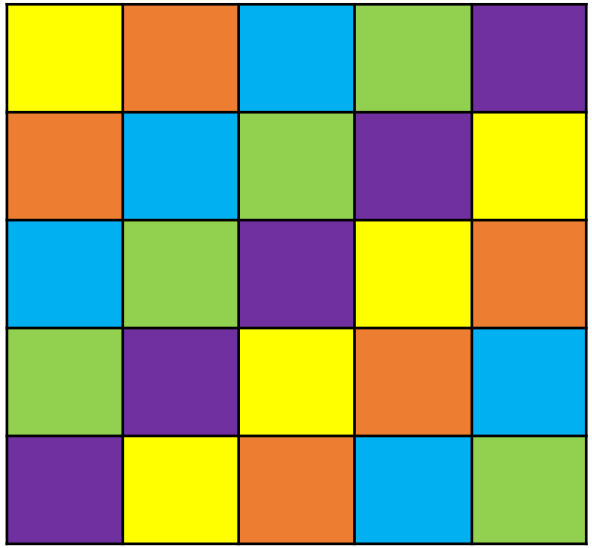
Optimal Sphere Packing Density



0	1	2	3	4	#Dim
density	1	$\frac{\pi}{\sqrt{12}} \approx 0.9068$	$\frac{\pi}{\sqrt{18}} \approx 0.7404$	$\frac{\pi^2}{16} \approx 0.6168$	

Coded Aperture Design Strategy

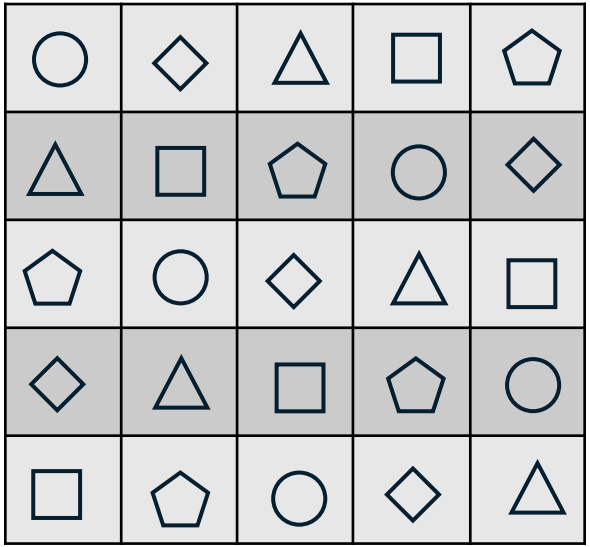
Temporal sampling



Army regiments

+

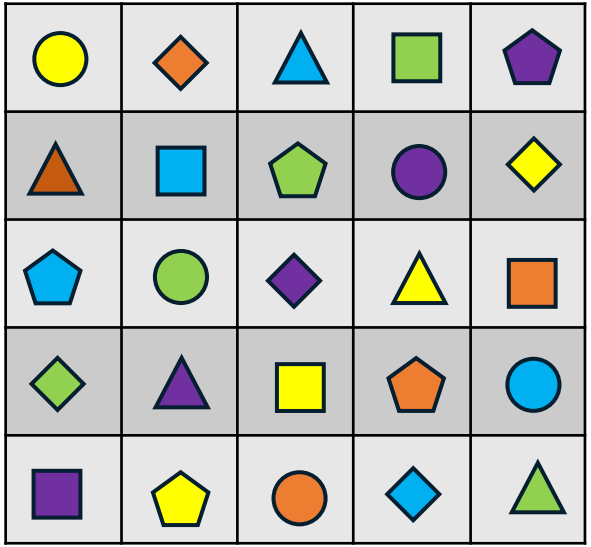
Spectral sampling



Army ranks

=

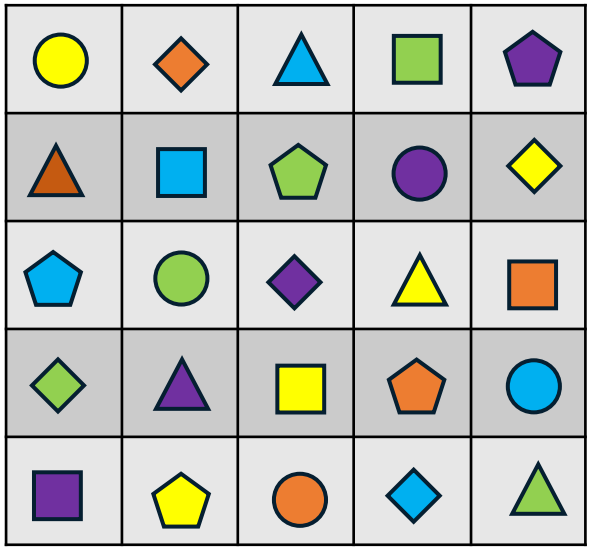
Spectral-video sampling



Leonhard Euler puzzle

Coded Aperture Design Strategy

Spectral-video sampling



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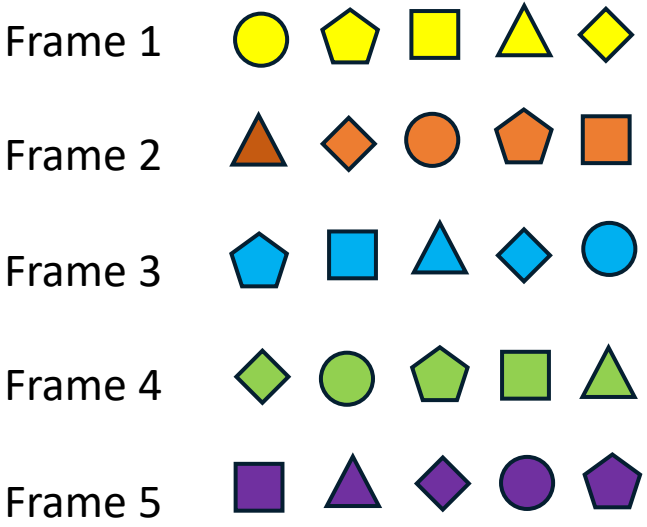
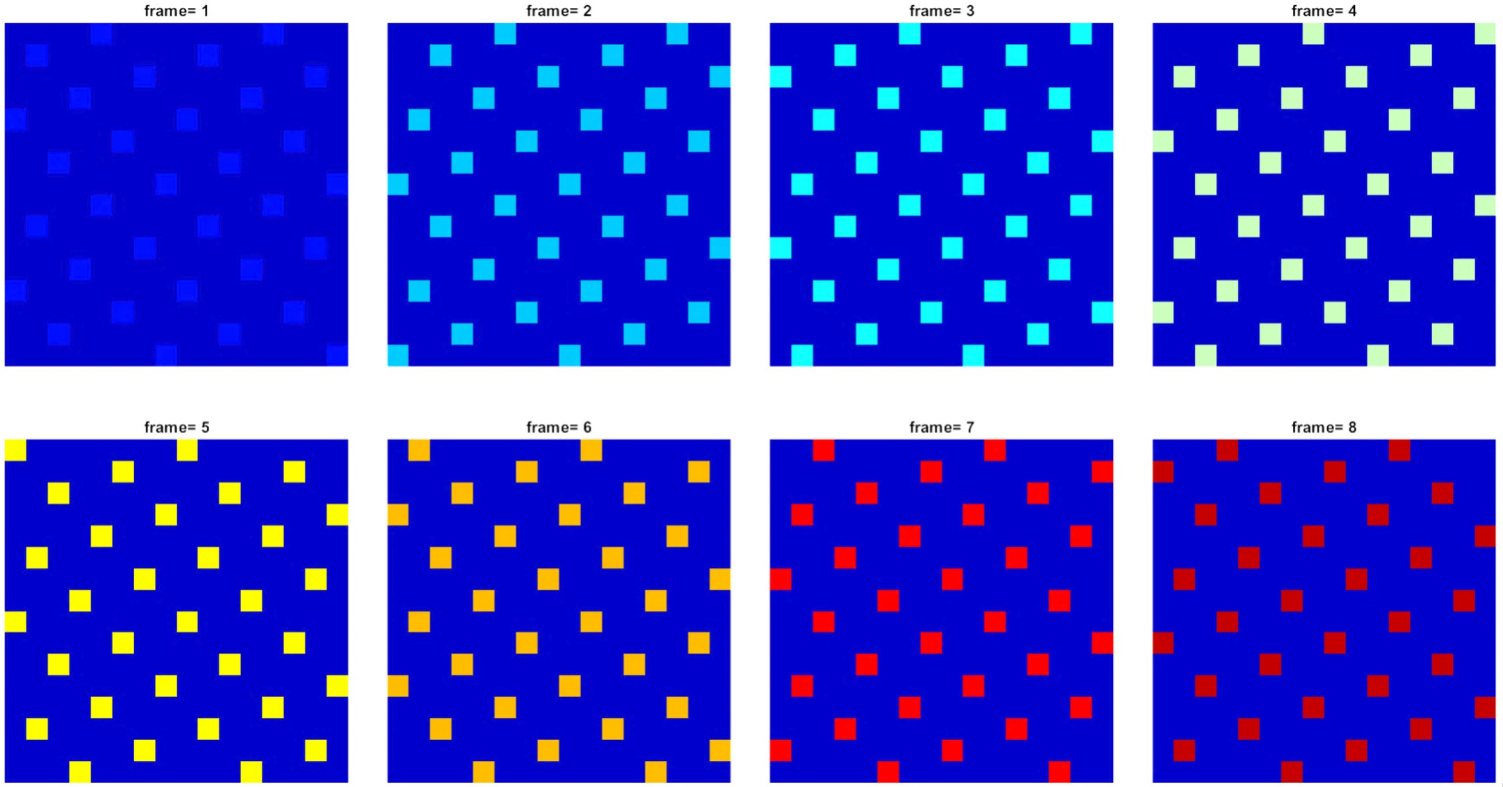
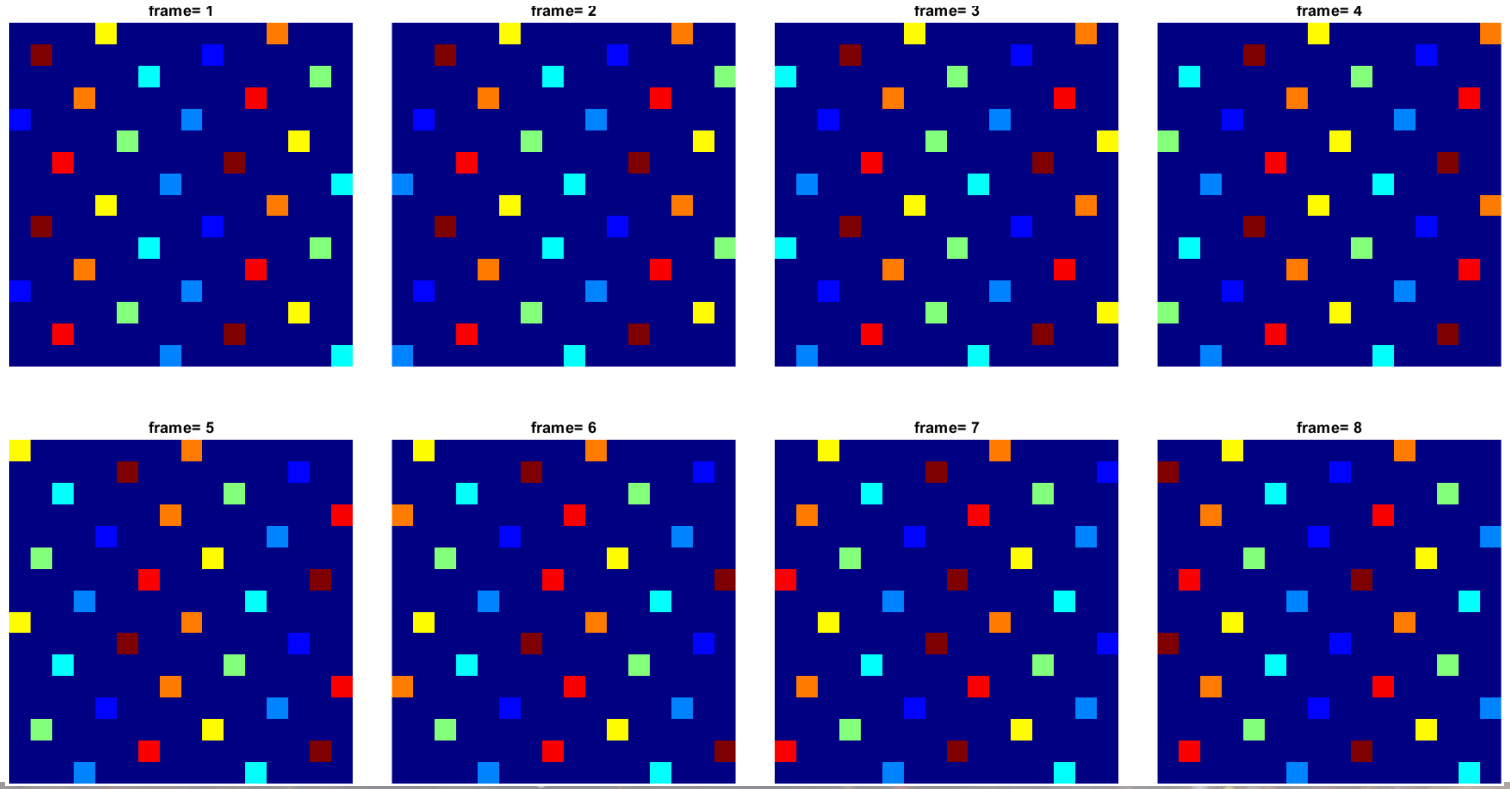


Temporal sampling

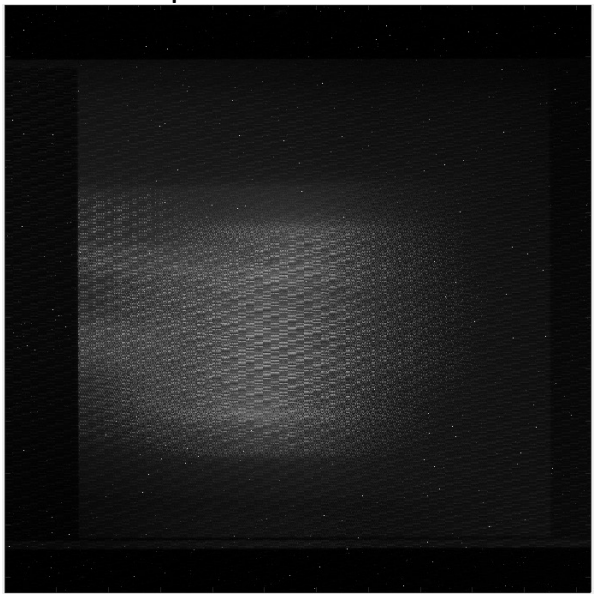


Spectral-video sampling



Spectral-Video Measurement

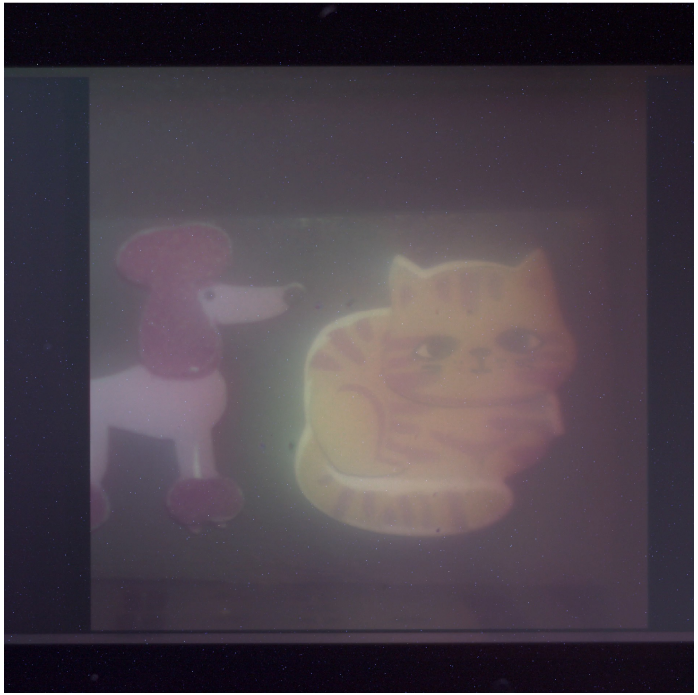
Snapshot measurement



1128 x 1128

Reconstruction Results

Spectral-video Groundtruth



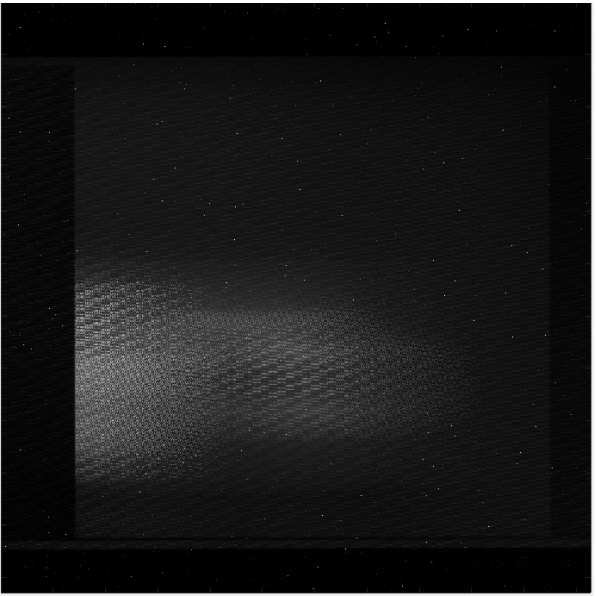
1128 x 1128 x 16 x 16

Spectral-video reconstruction

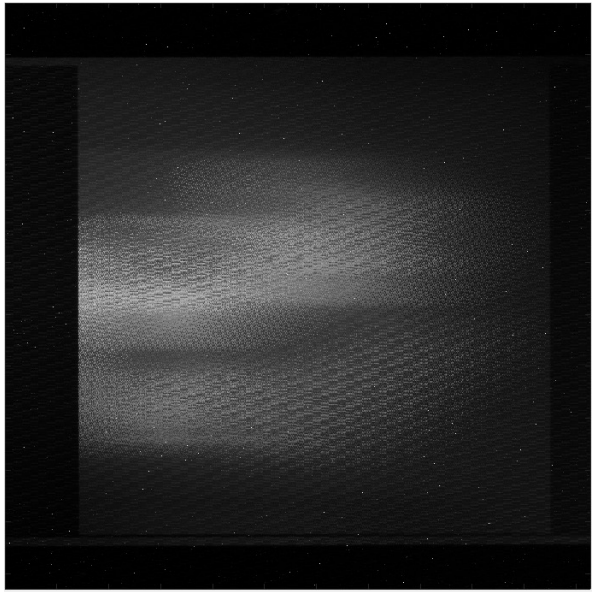
PSNR 26.96 dB, SSIM 0.79, SAM 0.24

Spectral-Video Measurement of 3 different Scenes

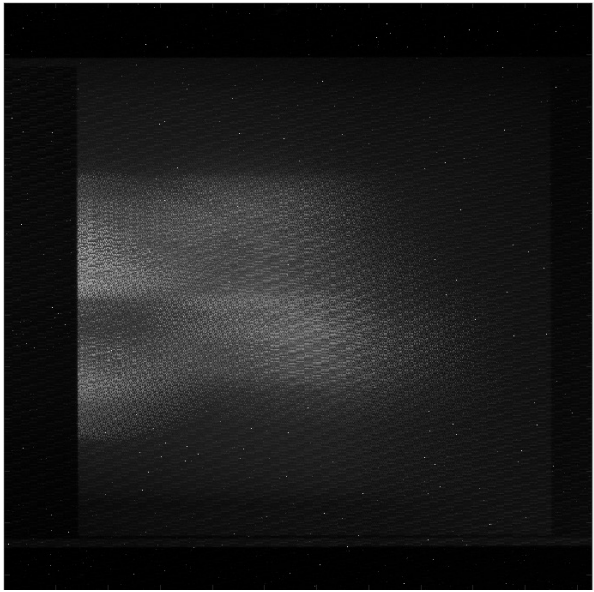
Scene 1



Scene 2

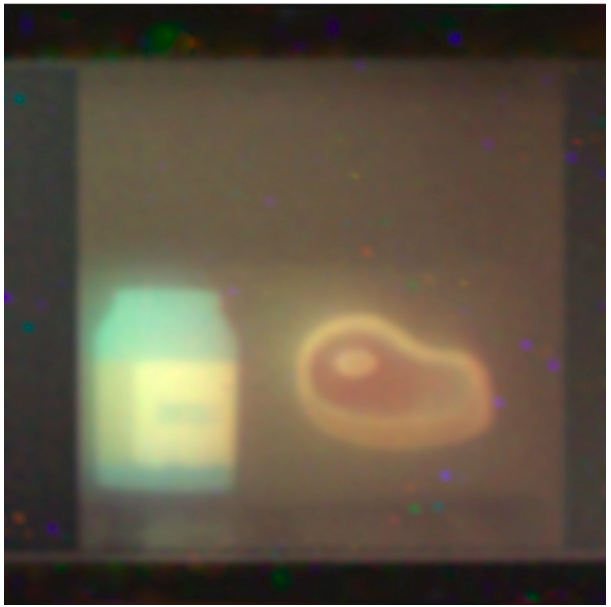


Scene 3



Reconstruction Results

Reconstruction Scene 1

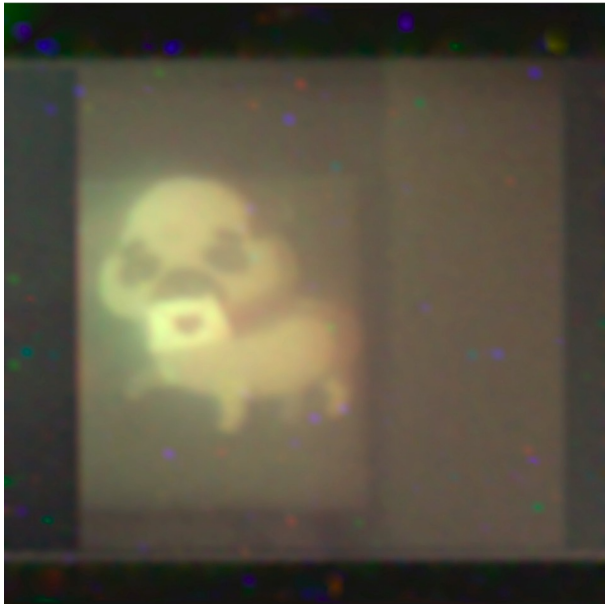


PSNR 28.02 dB, SAM 0.25

Reconstruction Scene 2

PSNR 28.02 dB, SAM 0.22

Reconstruction Scene3

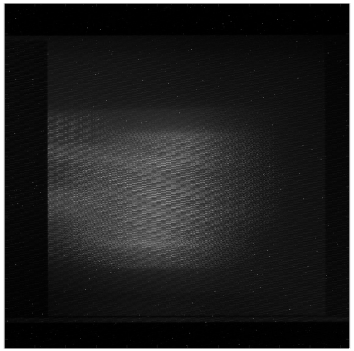


PSNR 27.07 dB, SAM 0.23

Conclusions

- We introduced a novel compressive spectral-video sensing approach that exploits optimal sphere packing.
- Our approach is able to accurately recover a spectral video from a single snapshot.
- The proposed approach obtains image reconstruction quality up to 26.96 [dB] of PSNR and 0.24 of SAM.

Compressive measurement



1128 x 1128

Groundtruth

1128 x 1128 x 16 x 16

Reconstruction

PSNR 26.96 dB, SAM 0.24

Thank you!

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https://nelson-diaz.com/

Agencia Nacional de Investigación y Desarrollo

Ministerio de Ciencia, Tecnología, Conocimiento e Innovación

Gobierno de Chile

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