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VISIGRAPP

Compressive Spectral Light Field Compact Image

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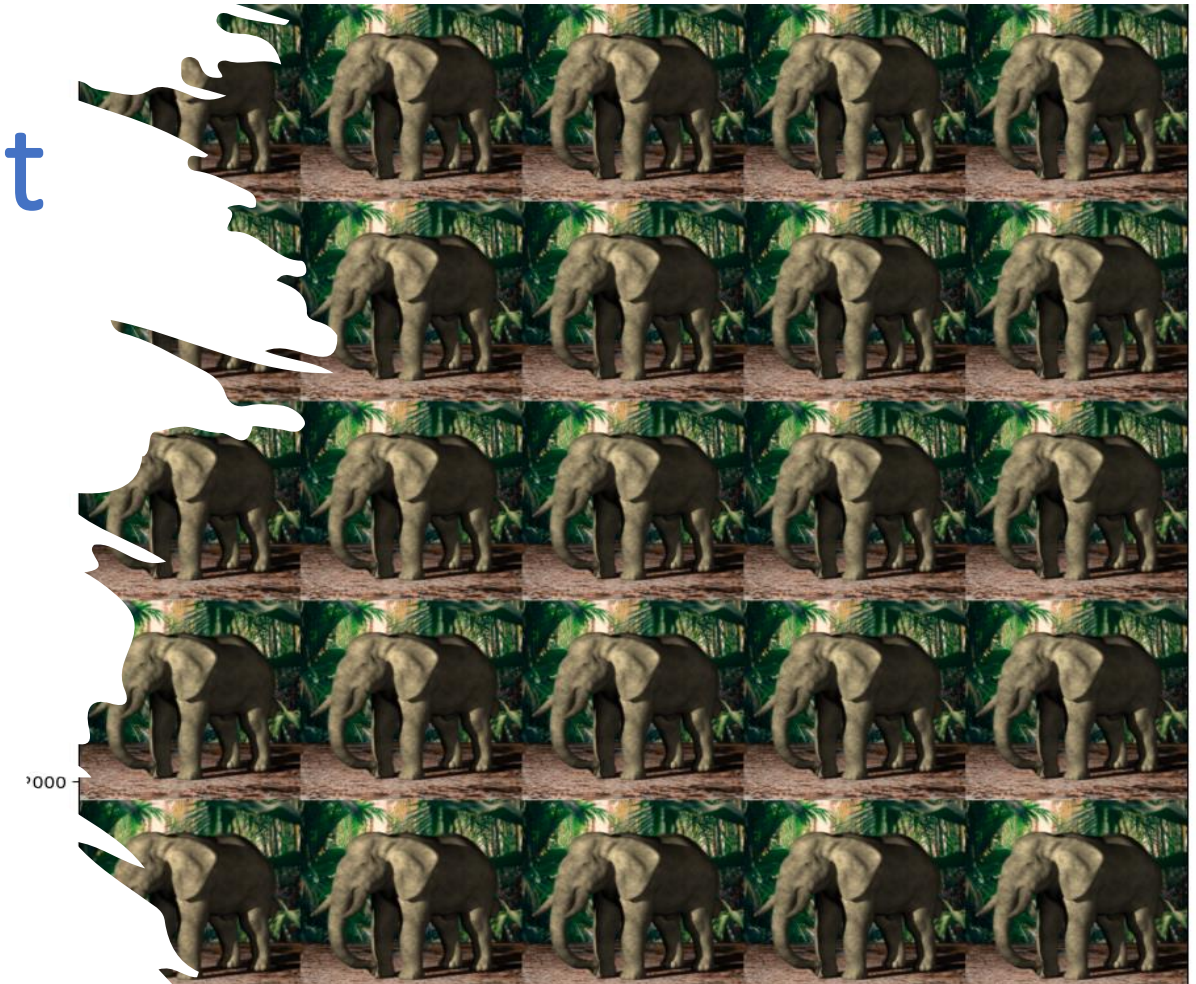
PRIME



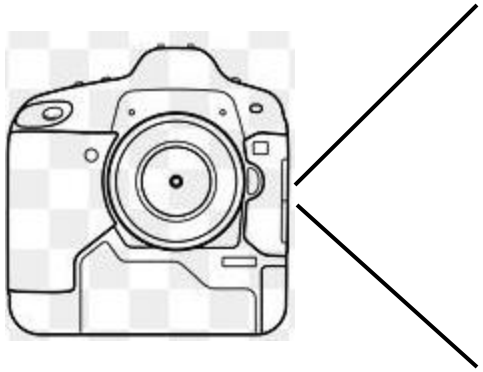
Contents

- **Spectral Light Field Cameras**
- **Compressive Spectral Light Field Image and Previous Methods**
- **Results and Comparison**

Contents

- **Spectral Light Field Cameras**
- Light Field and Spectral Light Field Capture
- Compressive Spectral Light Field Image
- Results

Conventional Cameras



A single Image

Light Field

Light Field: The light field consists of the total of all light rays in 3D space, flowing through every point and **in several directions**.

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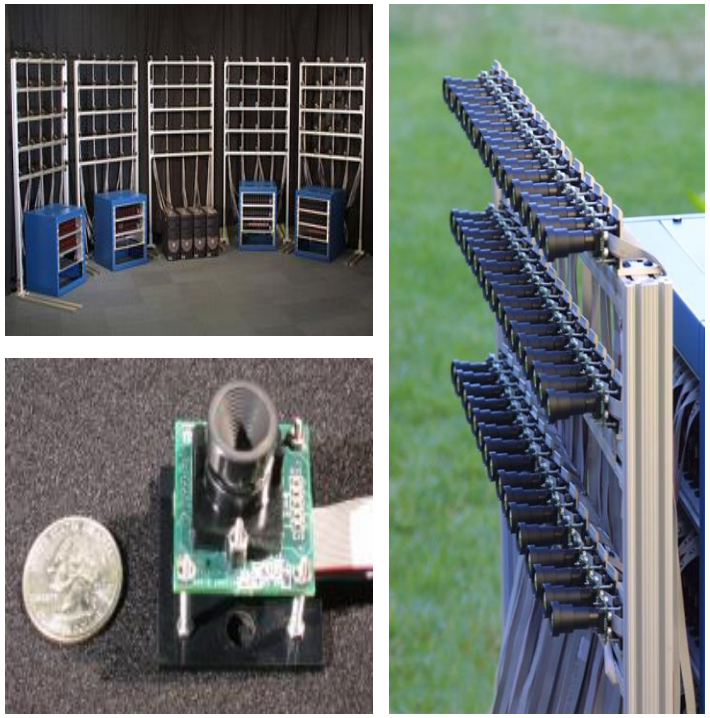
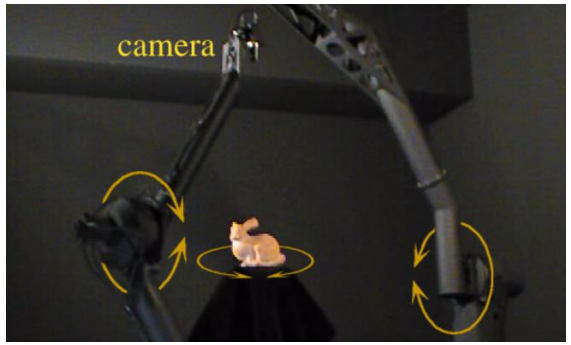
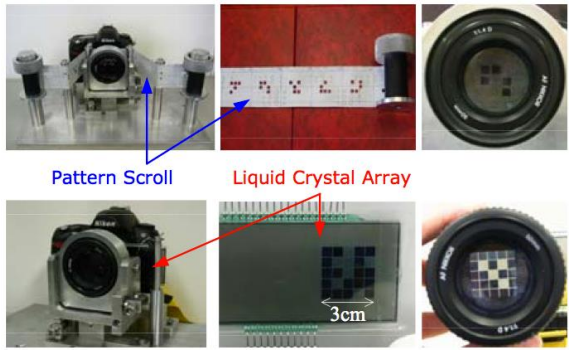
Light Field Capture



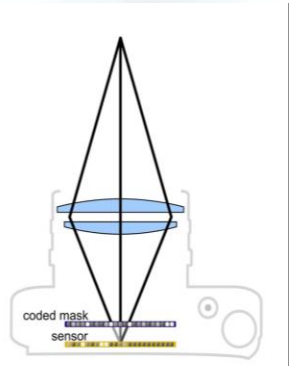
Camera Arrays
e.g., [Wilburn et al. 2002,2005]



Sequential Acquisition
e.g., [Levoy and Hanrahan 1996],



Mask Coded Camera
e.g.,[Liang et al. 2008]



Mask Coded Camera
e.g., [K. Marwah et al. 2013]

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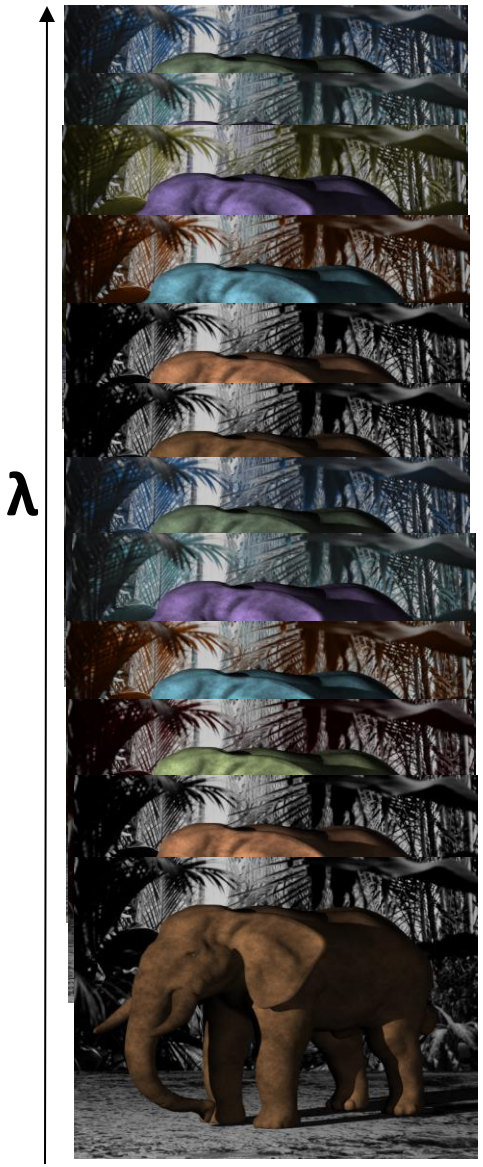
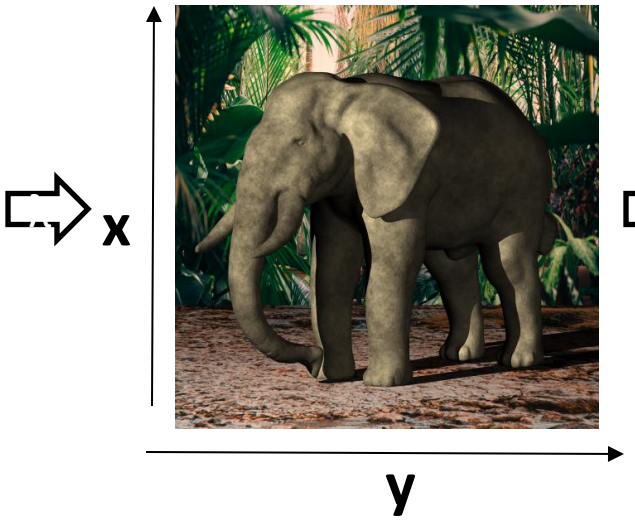
Spectral Light Field

$L(x, y, \mu, v, \lambda)$



Spectral Domain

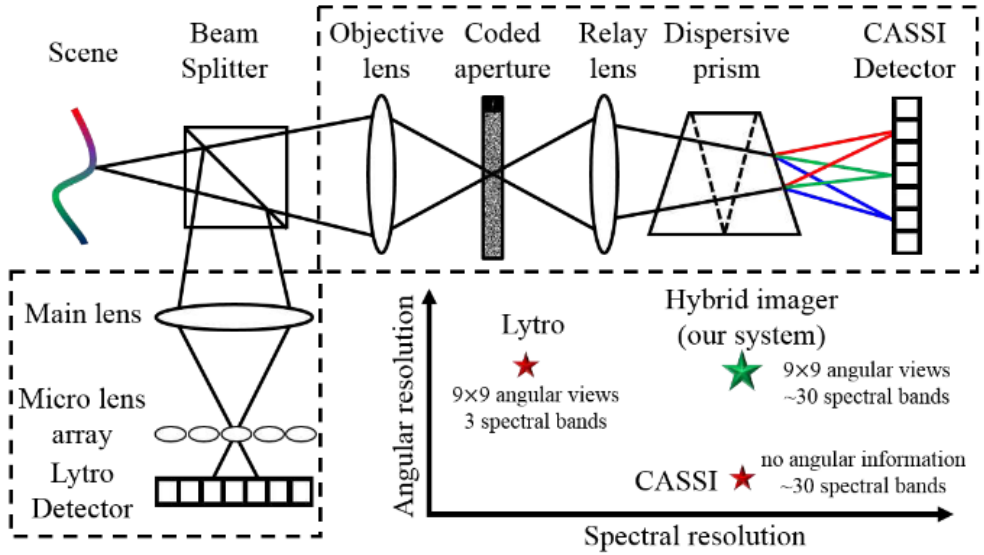


Spatial Domain

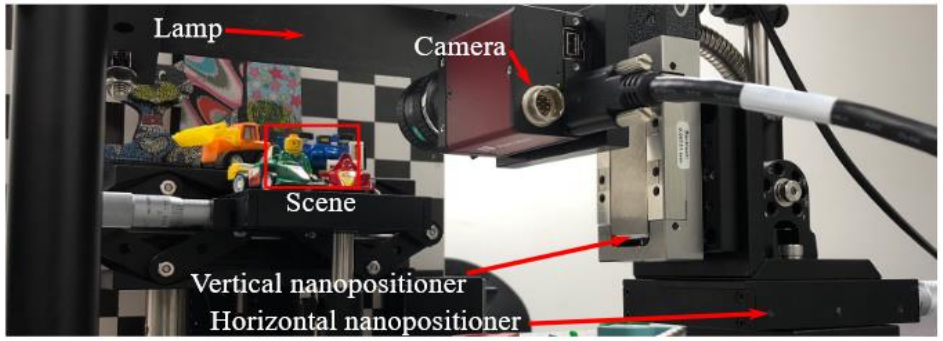
Angular Domain

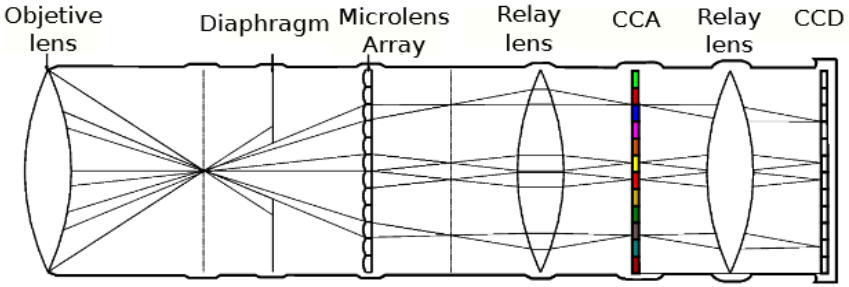
$L(x, y, \mu, v, \lambda)$

Spectral Light Field Capture



Micro Lens Array combines with a spectrometer
e.g., [Zhiwei Xiong et al. 2017]





Micro Lens Array combines with a CCA filter
e.g., [Miguel Marquezet al. 2015]

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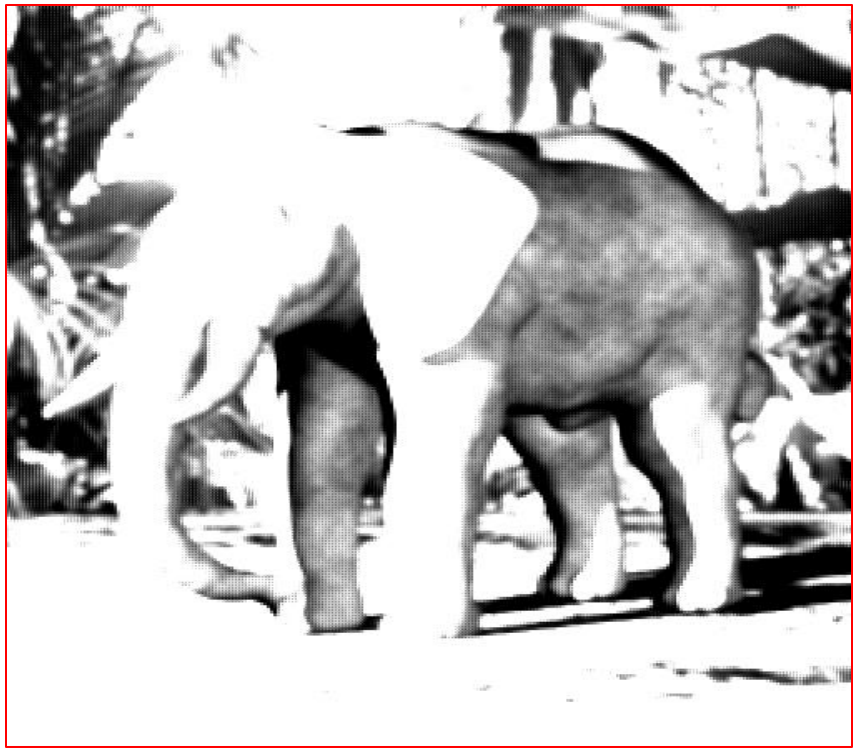
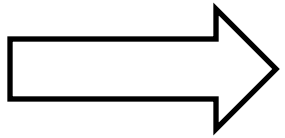
Our Goal: Recover Spectral Light Field





Inputs: 2D Coded Sensor Images of Scene

Outputs:5D Spectral Light Field of Same Scene

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Motivation

- Complicated optical system limit the spectral light field image's application

- Conventional Compressive Sensing Method takes several hours to recover the entire information

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Proposed Method

- a **compact spectral light field** Image

- a **multidimensional compressive sensing** method to decrease the computation time.

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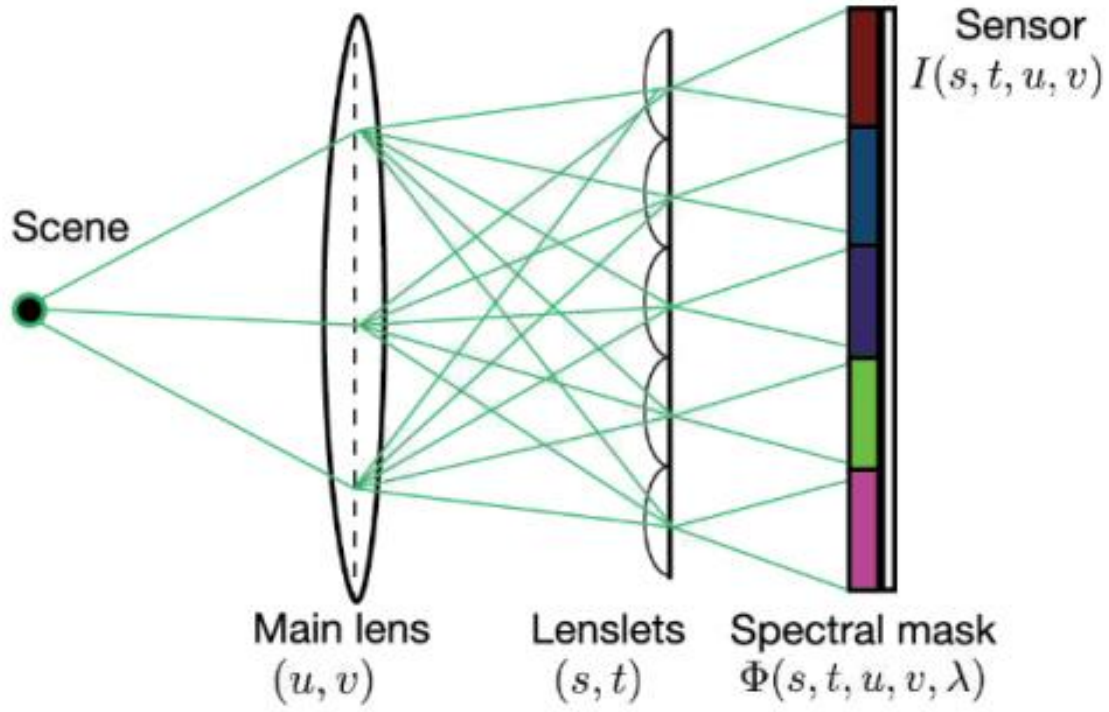
Our Compact Optical Image



- Compressed light fields are captured using a lenslet array placed in the optical path and a one-hot spectral mask placed on the sensor.

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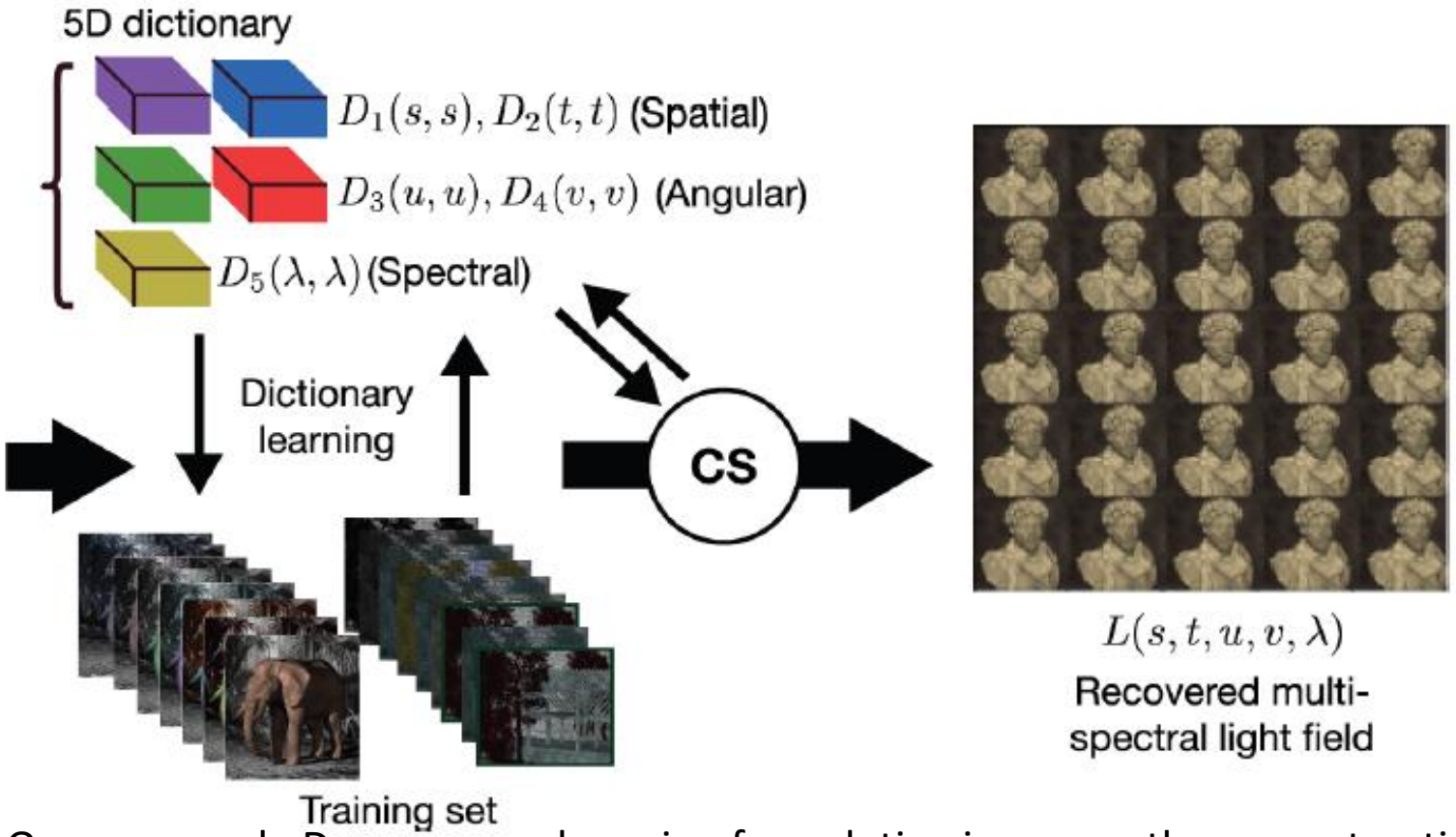
Compressed sensing framework



- Our proposed nD compressed sensing formulation improves the reconstruction time by orders of magnitude as compared to the commonly used 1D compressed sensing techniques without any quality degradation.

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Proposed Method

----Key Points

- A novel **spectral-coded mask** for modulating the spectral and spatial-angular information **simultaneously.**

- A 5D **compressed sensing method** is used to reconstruct the full light field information from the **under-sampled measurement**

- Apply a **five-dimensional basis and masks** that fit the characteristics of the spectral light field data

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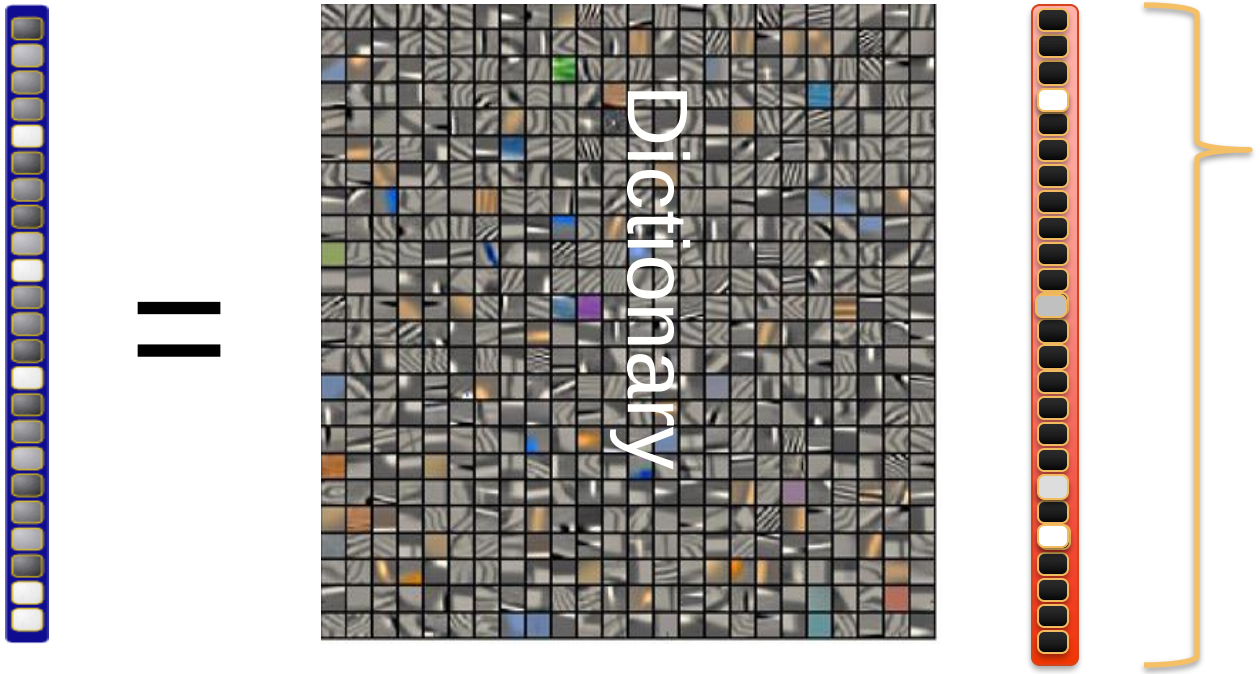
Compressive Spectral Light Field Representation

$l = \mathcal{D}\,\alpha$ such that α is *sparse*

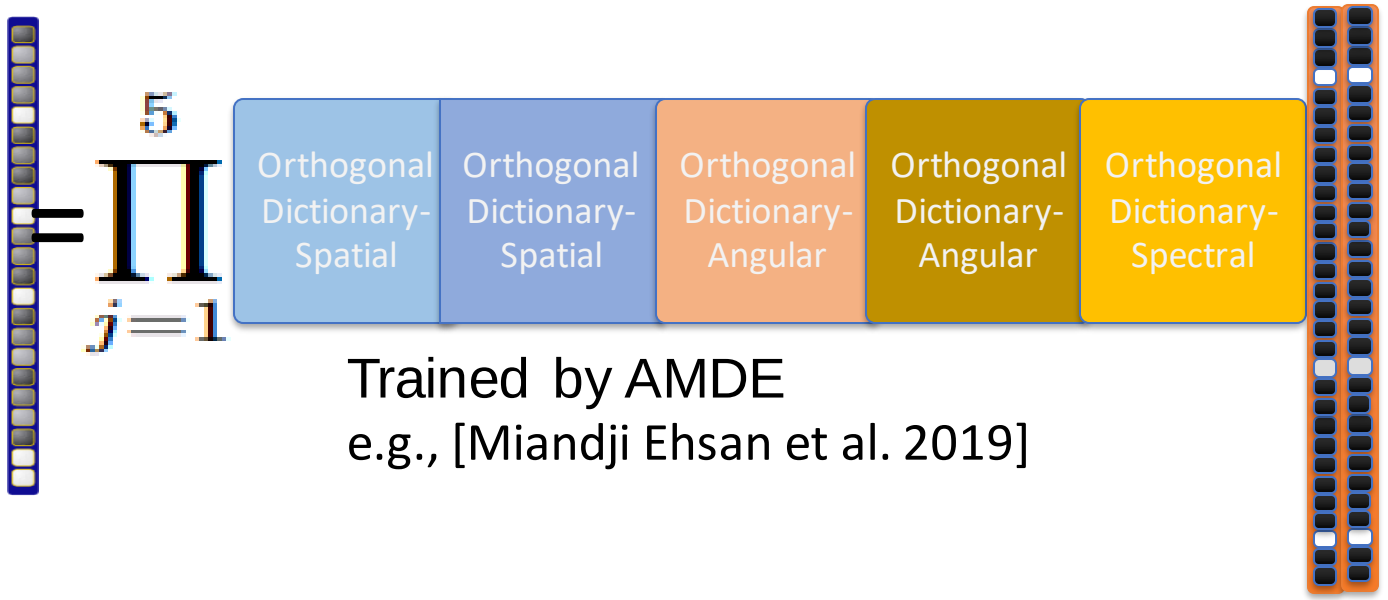
Light field vector — Basis matrix — Coefficient vector



Only a few non-zero coefficients

Multidimensional Dictionaries

$$\mathbf{l} = \prod_{j=1}^{5} D_j \times_j \boldsymbol{\alpha}$$



Trained by AMDE

e.g., [Miandji Ehsan et al. 2019]

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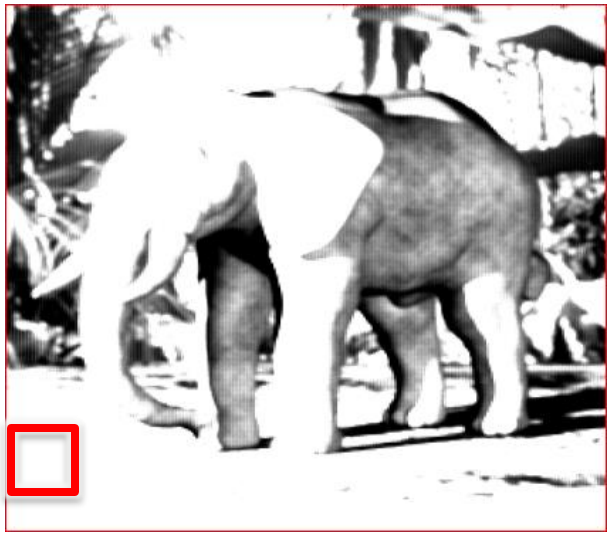
Compressive Spectral Light Field Image

Captured 2D Image



$$\underset{S}{argmin}\,\|S\|_0 \quad \text{s.t.} \quad \|I - S \times_1 \Phi_1 D_1 \times_2 \Phi_2 D_2 \times_3 \Phi_3 D_3 \times_4 \Phi_4 D_4 \times_5 \Phi_5 D_5\|_2 \leq \varepsilon, \quad (7)$$

5D Reconstruction

Solved by nd-SL0

e.g., [Gorodnitsky Irina et al. 2010]

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Results and Comparison ---Image Quality

Table 1: Comparing 5D DCT, 1D AMDE and 5D AMDE using five test spectral light fields under ONE snapshot. Proposed Method in blue. Best values in bold.

Test	Methods	PSNR /dB		SSIM			SA/(°)		
Scenes	5D DCT	1D AMDE	5D AMDE	5D DCT	1D AMDE	5D AMDE	5D DCT	1D AMDE	5D AMDE
Bust	25.388	31.944	31.944	0.741	0.812	0.812	22.6658	10.853	10.853
Cabin	15.798	20.275	20.2754	0.302	0.636	0.636	53.767	26.977	26.977
Circles	15.459	18.494	18.494	0.313	0.530	0.530	35.216	29.588	29.588
Dots	15.454	23.485	23.485	0.247	0.738	0.738	24.661	10.668	10.668
Elephants	18.108	24.880	24.880	0.5761	0.743	0.7435	23.161	17.356	17.356
Average	14.631	**22.398**	**22.398**	0.324	**0.627**	**0.627**	35.54	**24.804**	**24.804**

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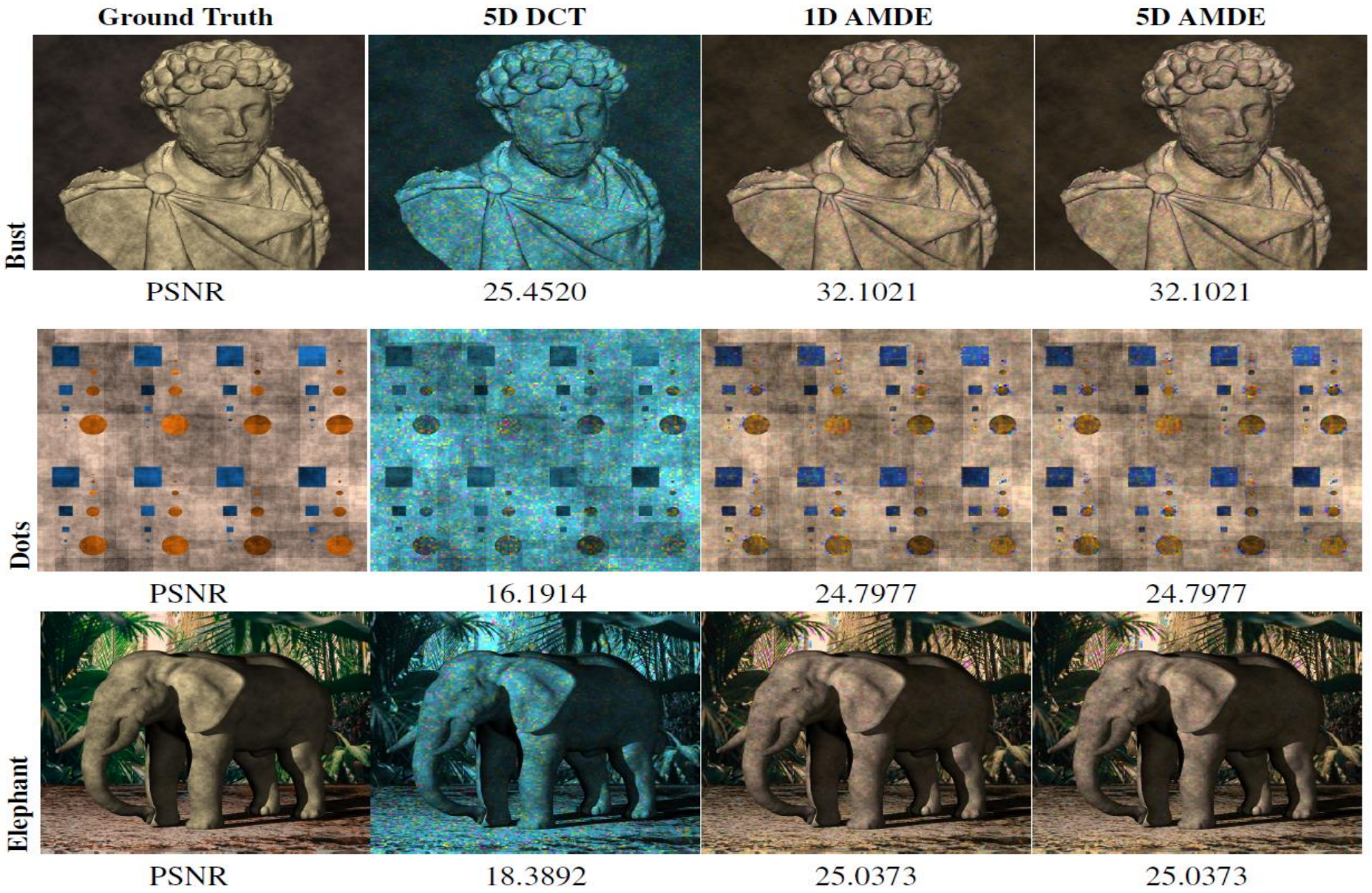

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Results and Comparison ---Time

Table 2: Average Reconstruction Time of 5D DCT, 1D AMDE and 5D AMDE per spectral light field using ONE snapshot.

Methods	Reconstruction Time
5D DCT	40.3 seconds
1D AMDE	2.4 hour
5D AMDE	79.5 seconds

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Results and Comparison ----Conclusion

- The results show that our novel nD formulation and the resulting 5D multidimensional sensing mask perform as expected with PSNR, SSIM, and SA on par with the 1D approach.

- The important difference, however, is that the nD formulation is orders of magnitudefaster, specifically 106 times faster,

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Thank you for Listening

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