



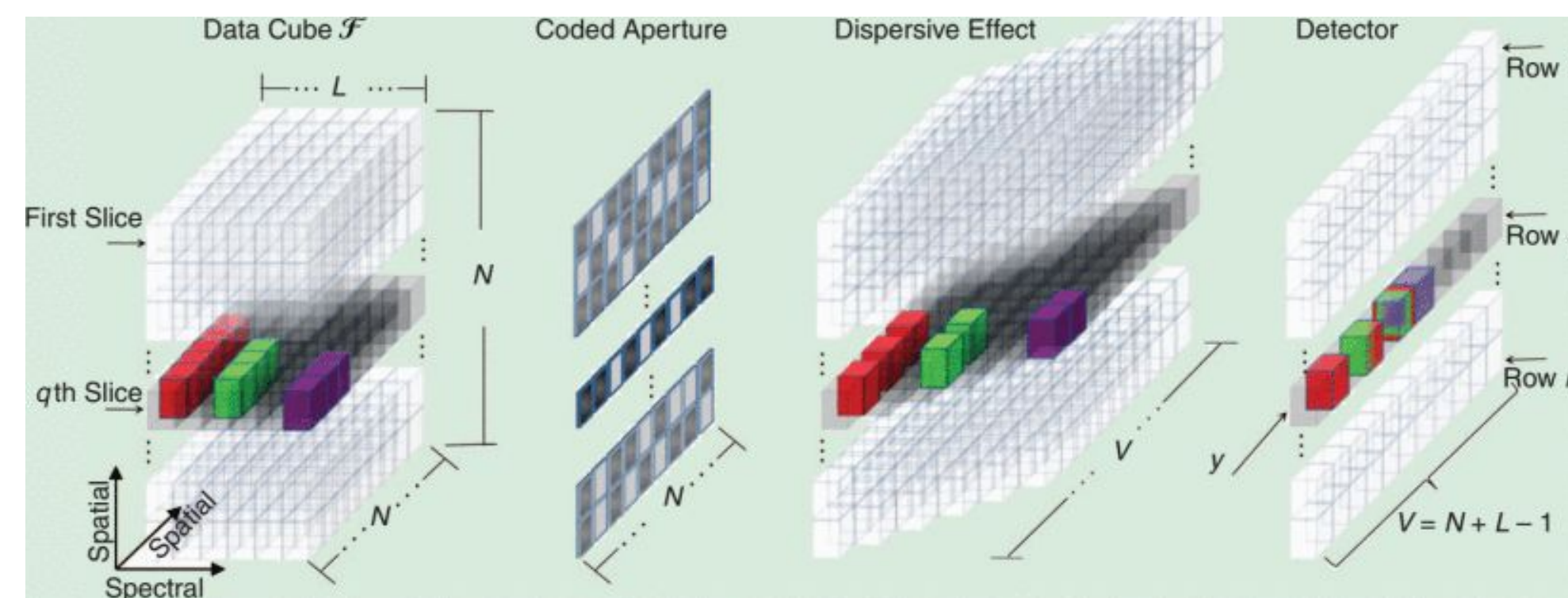
Compressive Hyperspectral Image Reconstruction with Variational Autoencoders

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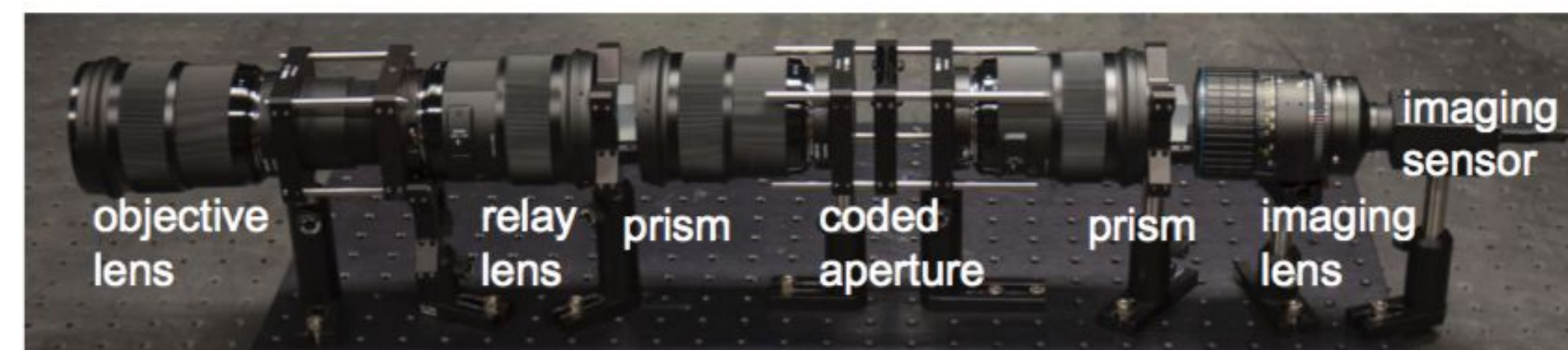


Motivation

Hyperspectral Image Reconstruction is the problem of extracting **spectral information** content in addition to the spatial information in a scene. Instead of reconstructing RGB channels, we reconstruct the entire 3D data cube with dimensions Height x Width x Wavelength.



CASSI (Coded Aperture Snapshot Spectral Imaging System) is a technique that captures a single 2D snapshot of the datacube, then utilizes optimization to reconstruct the full datacube.



Applications in **archaeology, environmental monitoring, and remote sensing**.

In this work, we attempted to **replicate the results from Choi, et. al 2017** (High-Quality Hyperspectral Reconstruction Using a Spectral Prior).

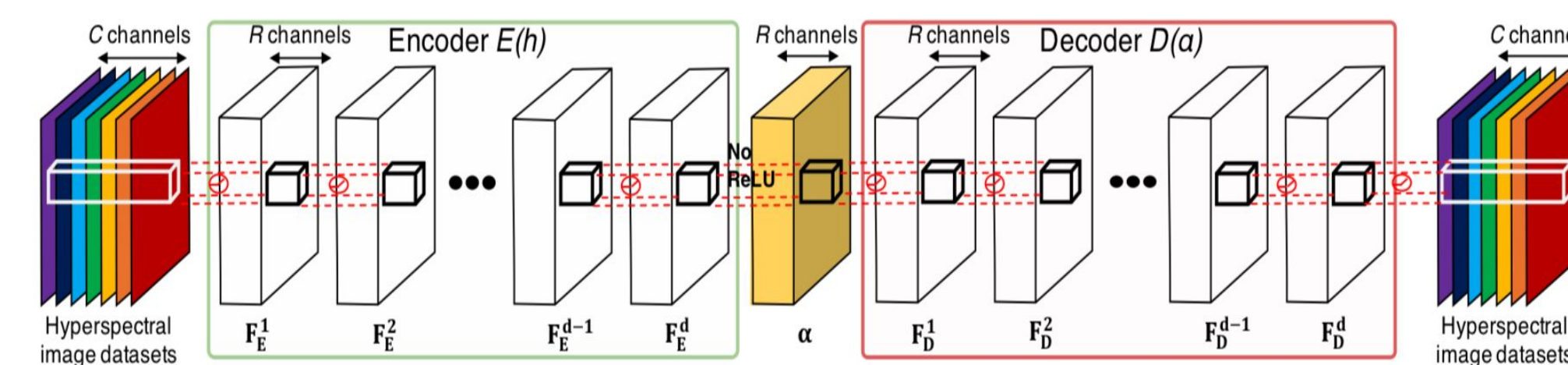
Data



We downloaded hyperspectral image data (full data cubes) from the KAIST and CAVE datasets and simulated CASSI using random binary masks. We used only the data corresponding to the wavelengths from 420nm to 700nm in 10nm increments.

Methods

Spectral Prior via Variational Autoencoder



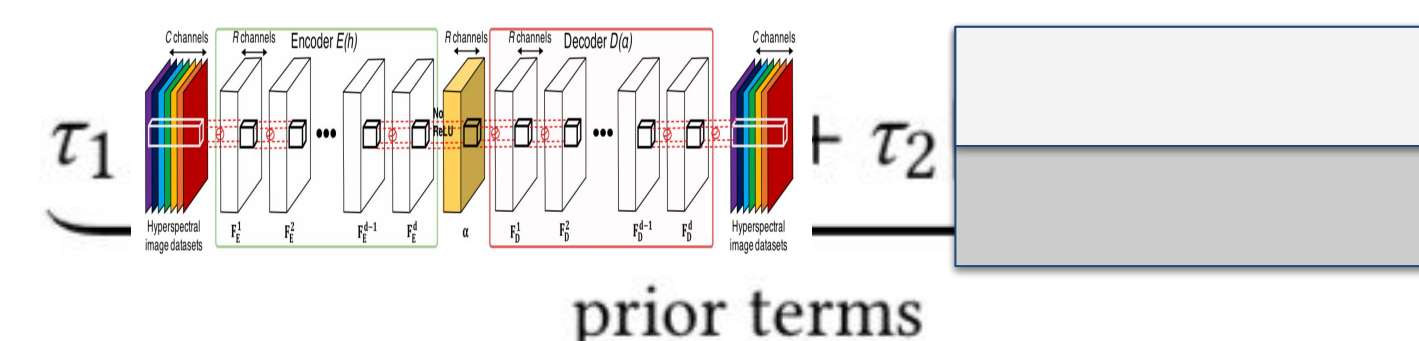
Input Channels (C)	29
Hidden Channels (R)	64
Hidden Layers (d)	11
Conv layers	3x3, pad 1

$$\frac{1}{2k} \sum_{i=1}^k \|A(h^{(i)}) - h^{(i)}\|^2 + \frac{\tau_w}{2} \sum_{l=1}^{d+1} (\|W_E^l\|^2 + \|W_D^l\|^2)$$

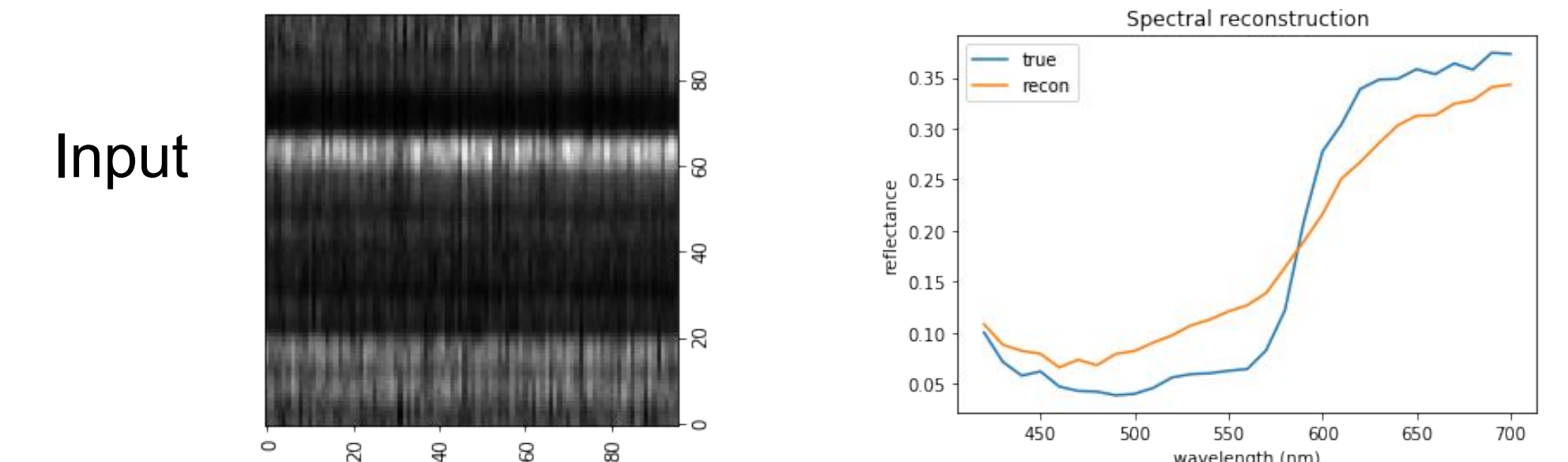
Reconstruction via ADMM

$$\min_{\alpha} \underbrace{\|i - \Phi D(\alpha)\|_2^2}_{\text{data terms}} + \underbrace{\tau_1 \|\alpha - E(D(\alpha))\|_2^2 + \tau_2 \|\nabla_{xy} D(\alpha)\|_1}_{\text{prior terms}}$$

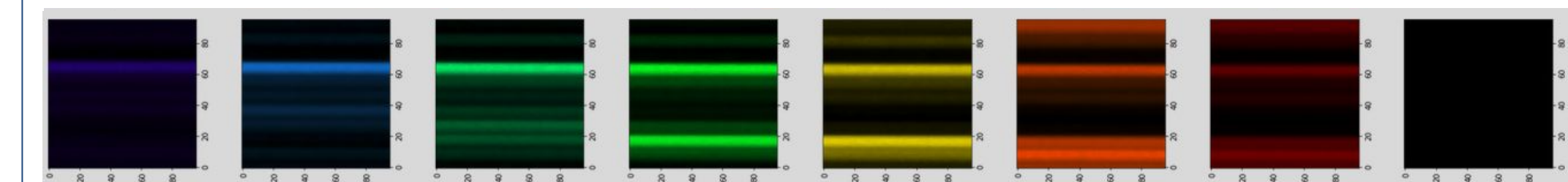
$$\min_{\alpha} \underbrace{\|i - \Phi D(\alpha)\|_2^2}_{\text{data terms}} + \underbrace{\tau_1 \|\alpha - E(D(\alpha))\|_2^2 + \tau_2 \|\nabla_{xy} D(\alpha)\|_1}_{\text{prior terms}}$$



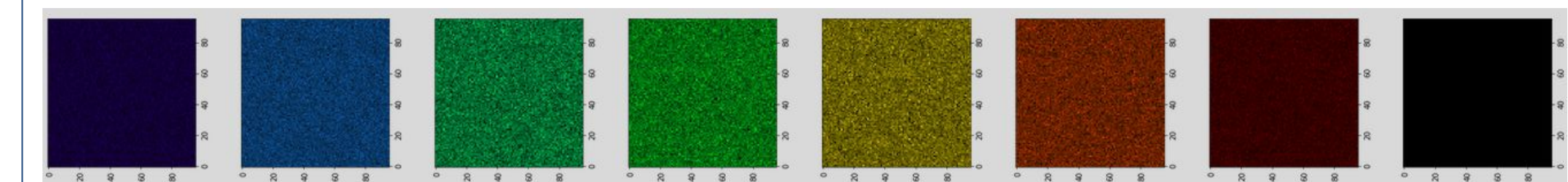
Results



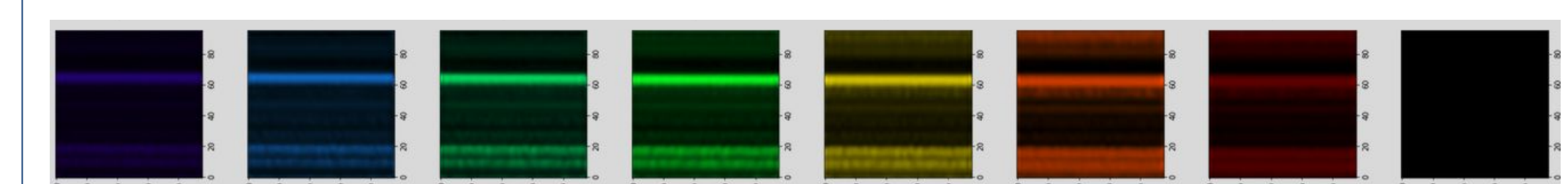
Ground Truth



Naive CS: PSNR = -1.89



This work: PSNR = 25.33



Discussion and Future Work

1. **Try a larger data set.** Because of the low PSNR (?).
2. **Use a stronger real-image prior** - instead of TV, use BM3D or some other natural image prior.
3. **Try using a GAN instead.** Might provide an interesting point of comparison, as both attempt to learn good latent representations.
4. **Try other applications** where compressed sensing or dictionaries are used, e.g. MRI, compressive light-field imaging.

References

I. Choi, D. S. Jeon, G. Nam, D. Gutierrez, and M. H. Kim. High-quality hyperspectral reconstruction using a spectral prior. ACM Transactions on Graphics (Proc. SIGGRAPH Asia 2017), 36(6):218:1–13, 2017.