Non-local Meets Global: An Integrated Paradigm for Hyperspectral Denoising

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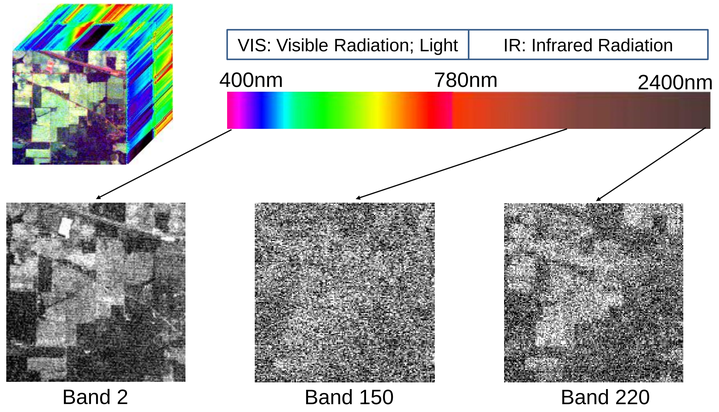
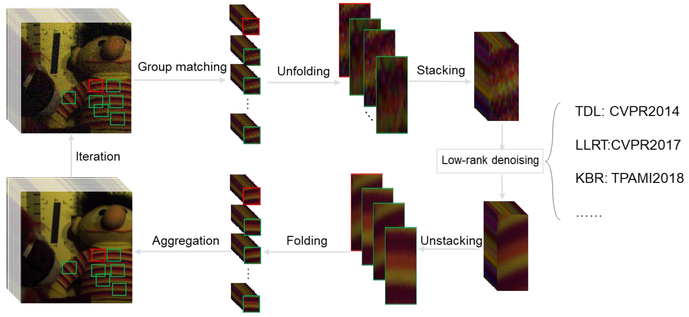
Background:

- Remote sensing hyperspectral image (HSI) has a high spectral resolution, it can imaging at every 10nm.
- HSI is always corrupted by noise.



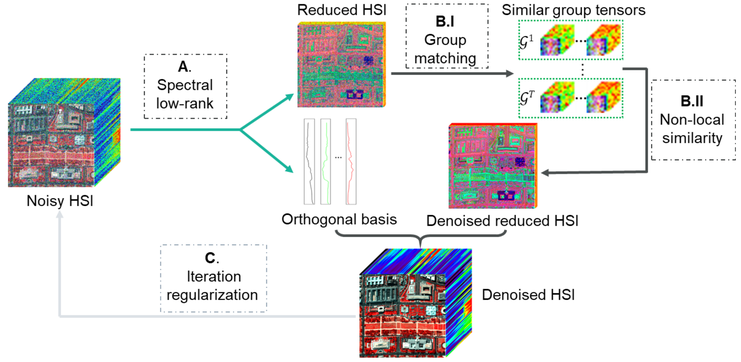
HSI denoising: non-local similarity

- State-of-the-art: non-local matrix/tensor denoising
- Full-band-patch grouping causes heavy computational burden with the increase of spectral bands



Non-local meets global (NGmeet):

- Assumption: the non-local similarity groups underlie a global spectral low-rank subspace.
- Main contribution: (i). A new model, jointly learn the projection and reduced image, with global spectral low-rank and spatial non-local low-rank. (ii). Iteration to refine the projection matrix.



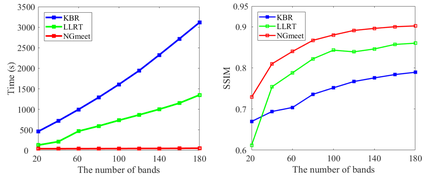
- Objective function: $\mathcal{Y}$ stands for the noisy HSI; $\mathbf{A}$ is the projection matrix; $\mathcal{M}$ represents the reduced image. The proposed model can be efficiently solved by alternative minimization.

$$\{\mathcal{M}_*, \mathbf{A}_*\} = \arg\min_{\mathcal{M},\mathbf{A}} \frac{1}{2}\|\mathcal{Y} \times_3 \mathbf{A}^\top - \mathcal{M}\|_F^2 + \mu\|\mathcal{M}\|_{\mathrm{NL}},$$
$$\text{s.t. } \mathbf{A}^\top\mathbf{A} = \mathbf{I}$$

Results:

- Dataset: CAVE of size $512 \times 512 \times 32$; Pavia of University (PaC) of size $200 \times 200 \times 80$; WDC of size $256 \times 256 \times 191$.
- Comparison methods: FastHyDe [3]; KBR [2], LLRT [1].
- Evaluation: mean PSNR (MPSNR) of the all bands.
- Noise level: noise variance of value 10, 30, 50 and 100.

Image	Noise level	Index	FastHyDe	KBR	LLRT	NGmeet
CAVE	10	MPSNR(dB)	46.722	46.204	47.137	**47.871**
	30	MPSNR(dB)	41.213	41.522	42.533	**43.112**
	50	MPSNR(dB)	38.046	39.409	40.088	**40.451**
	100	MPSNR(dB)	33.406	33.780	36.253	**37.206**
PaC	10	MPSNR(dB)	42.220	40.090	41.950	**43.170**
	30	MPSNR(dB)	35.980	34.390	35.040	**36.970**
	50	MPSNR(dB)	33.320	31.050	32.000	**34.290**
	100	MPSNR(dB)	29.900	27.800	28.630	**30.610**
WDC	10	MPSNR(dB)	43.060	40.580	41.890	**43.720**
	30	MPSNR(dB)	37.390	34.750	36.300	**37.900**
	50	MPSNR(dB)	34.610	31.610	33.480	**35.140**
	100	MPSNR(dB)	31.050	28.230	29.880	**31.450**



The computational time and SSIM values of different numbers of bands. WDC is used and noise variance is 100.

Conclusion:

- We proposed a new perspective to integrate the spatial non-local similarity and global spectral low-rank property, which are explored by low-dimensional projection and reduced image denoising, respectively. In future, we plan to adopt Convolutional Neural Network to explore non-local similarity; and automated machine learning to help tuning and configuring hyper-parameters.

Reference:

[1] Y. Chang, L. Yan, and S. Zhong. Hyper-laplacian regularized unidirectional low-rank tensor recovery for multispectral image denoising. In CVPR, 2017.
[2] Q. Xie, Q. Zhao, D. Meng, and Z. Xu. Kronecker-basis-representation based tensor sparsity and its applications to tensor recovery. TPAMI, 2018.
[3] L. Zhuang and J. M. Bioucas-Dias. Fast hyperspectral image denoising and inpainting based on low-rank and sparse representations. J-stars, 2018.