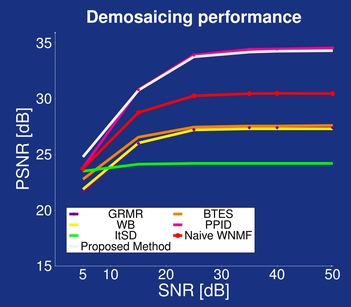
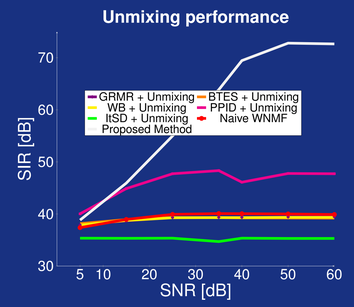
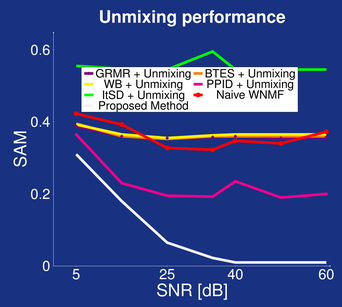
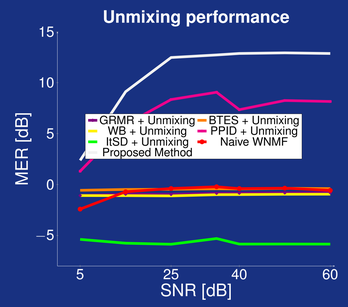
Performing **unmixing after demosaicing** SSI images is **not** a **good** strategy. Instead, **unmixing from** the **SSI** data is **far better**!









Joint Unmixing and Demosaicing Methods for Snapshot Spectral Images

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Snapshot Spectral Imaging (SSI)

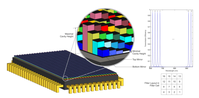
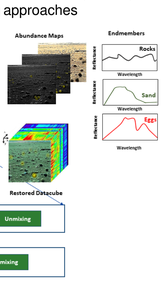


Figure: SSI cameras associate each spatial pixel with a specific spectral band.

Figure: The SnapShot SWIR camera from IMEC using a mosaic pattern of 16 SWIR filters.

- Demosaicing = providing a datacube with full spectral information & good spatial resolution.
- Various approaches have been proposed:
  - Weighted bilinear interpolation (WB)
  - Iterative Spectral Difference (ItSD)
  - Multispectral demosaicing approach using a pseudo-panchromatic image (PPID)
  - Binary Tree-Based Generic Demosaicing (BTES)
  - Graph and rank regularized method (GRMR)
  - Multiple Deep Learning approaches



⚠ Performing classification **after** demosaicing provides a poor classification performance [1]

- In [2], **joint** low-rank matrix completion and factorization far more accurate than a two-stage approach.

➪ Joint Demosaicing and Unmixing more efficient than a two-stage approach?

Naive Method

- Weighted Non-negative Matrix Factorization (WNMF) is used to solve the joint demosaicing and unmixing problem.

$$\hat{Y} = W \circ X + (\mathbb{1}_{(m \cdot n) \times k} - W) \circ (G \cdot F), \quad (1)$$

- W denotes a binary weight matrix whose nonzero entries allow to select which wavelength is observed by the camera in the case of ideal filter.
- Can be solved using Expectation Maximization WNMF framework on the entire image. [3].
- The best demosaicing performance in average was achieved after dividing the image into rank-1 patches.

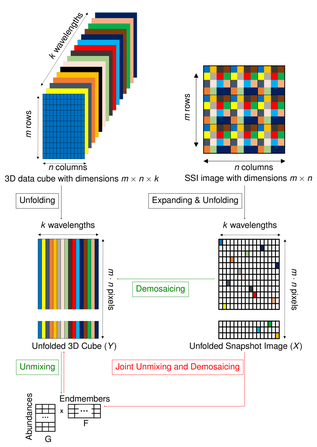
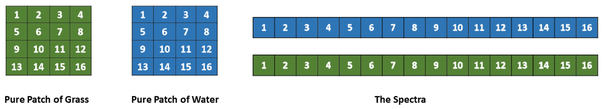


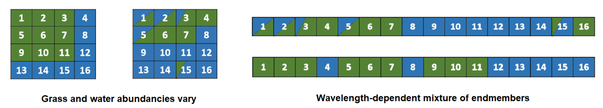
Figure: Principles of the two-step (in green) and joint (in red) strategies.

Assumptions required for the proposed method

- **Assumption 1 (Pure Patch Assumption)**
  For each endmember, there exists at least one sensor "patch" where only this endmember is present.

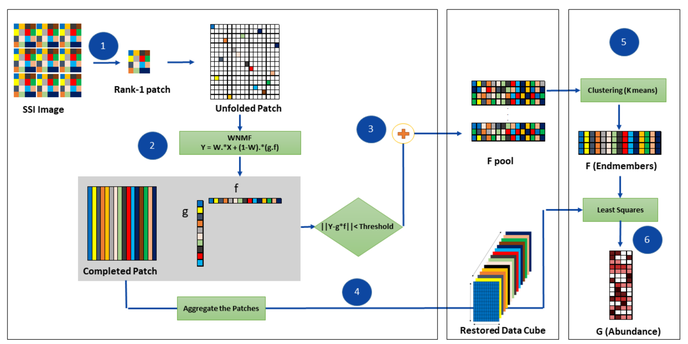


- **Assumption 2**
  In the patches where several endmembers are present, their abundances significantly vary over each patch.



- Assumption 1 and 2 are similar to the assumptions made in Sparse Component Analysis (SCA).

Proposed Low-rank Completion-Based Method



- K-means (resp. K-medians) Patch-based Weighted Non-negative Matrix Factorization (KPWNMF)
- Assumptions recently relaxed [4]

Experiments

- To assess the performance of the proposed method, we conduct experiments on SSI simulations derived from synthetic images and the CAVE dataset.
- We assume that the hyperspectral imagery is acquired using a SSI camera system, equipped with 5×5 and 4×4 spectral filter patterns.
- Reconstruction quality is measured in terms of Peak Signal-to-Noise Ratio (PSNR, in dB) while the unmixing enhancement is measured using Signal-to-Interference Ratio (SIR, in dB), Mixing Error Ration (MER, in dB) and Spectral Angel Mapper (SAM.)

Results

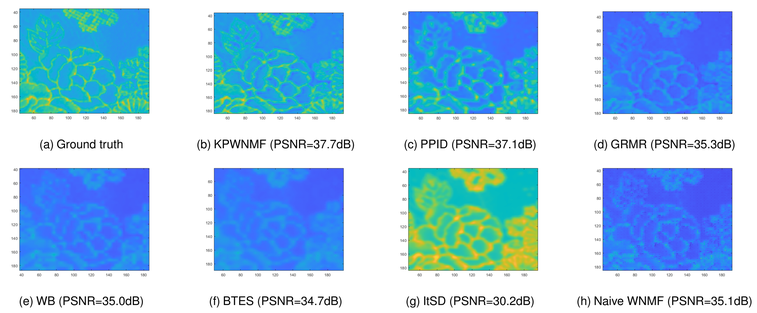


Figure: Demosaiced images obtained with KPWNMF and SotA methods for the 4×4 patch, and PSNRs averaged over all the images.

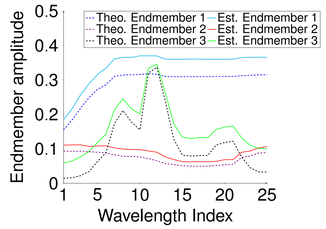


Figure: KPWNMF estimated spectra for complex image

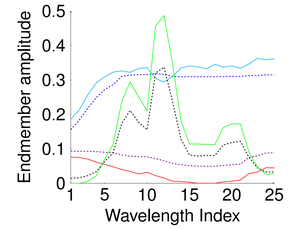


Figure: PPID estimated spectra for complex image

Conclusion and Future Work

- The proposed method provides a slightly better demosaicing performance than state-of-the-art methods and a much higher unmixing enhancement.
- We aim to investigate the use of our proposed methods on real SSI data.
- We also aim to extend them to the case when endmember spectral variability is met in the acquisition process.

Acknowledgements and References

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[1] G. Tsagkatakis, M. Bloemen, B. Geelen, M. Jayapala, and P. Tsakalides. "Graph and Rank Regularized Matrix Recovery for Snapshot Spectral Image Demosaicing". In: *IEEE Trans. Comput. Imaging* 5.2 (June 2019), pp. 301–316.

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