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# Joint Demosaicing and Unmixing in Hyperspectral Videos

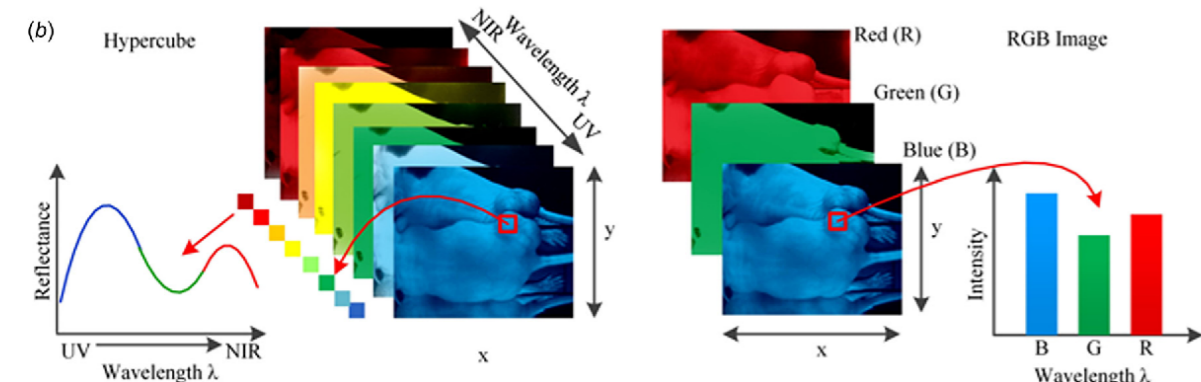
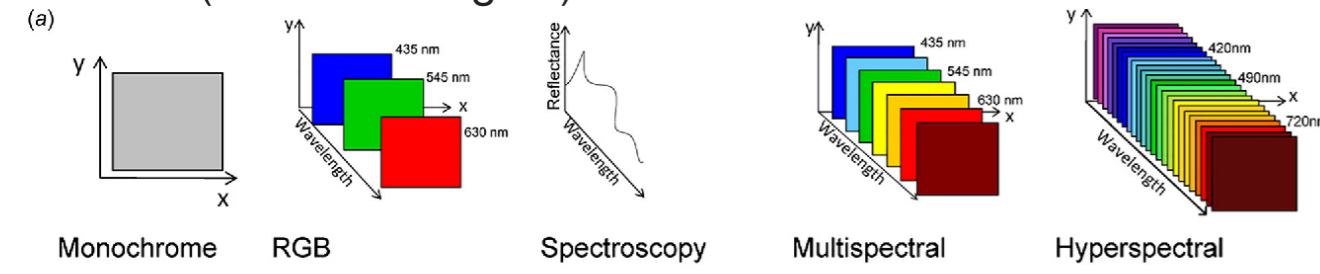


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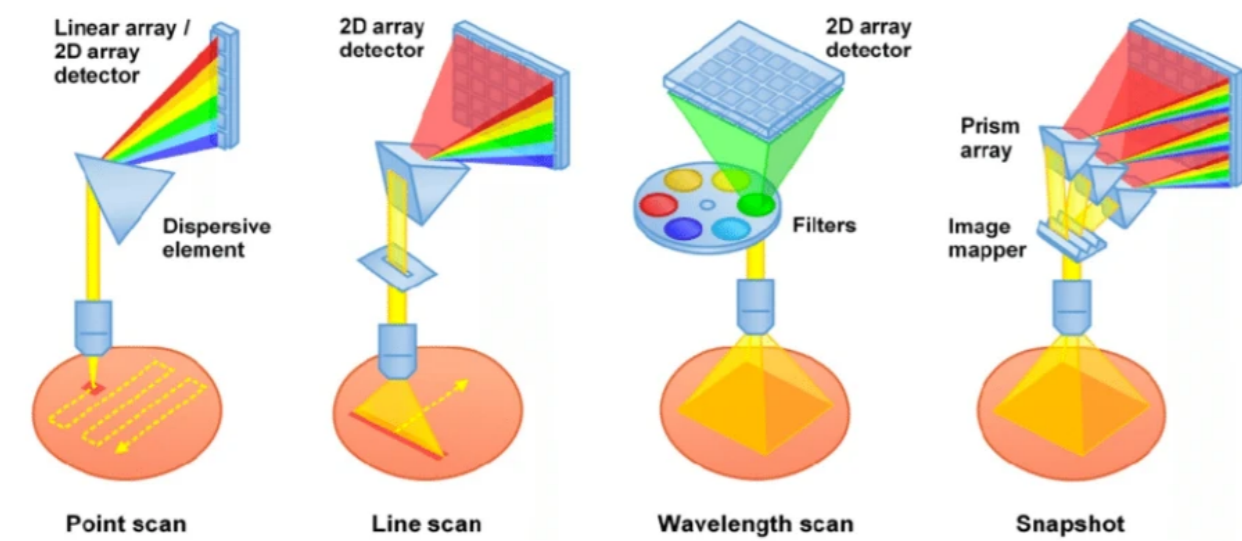
## Hyperspectral Imaging (HSI)

- Hyperspectral cameras allow to see objects in many "colors" (aka wavelengths)



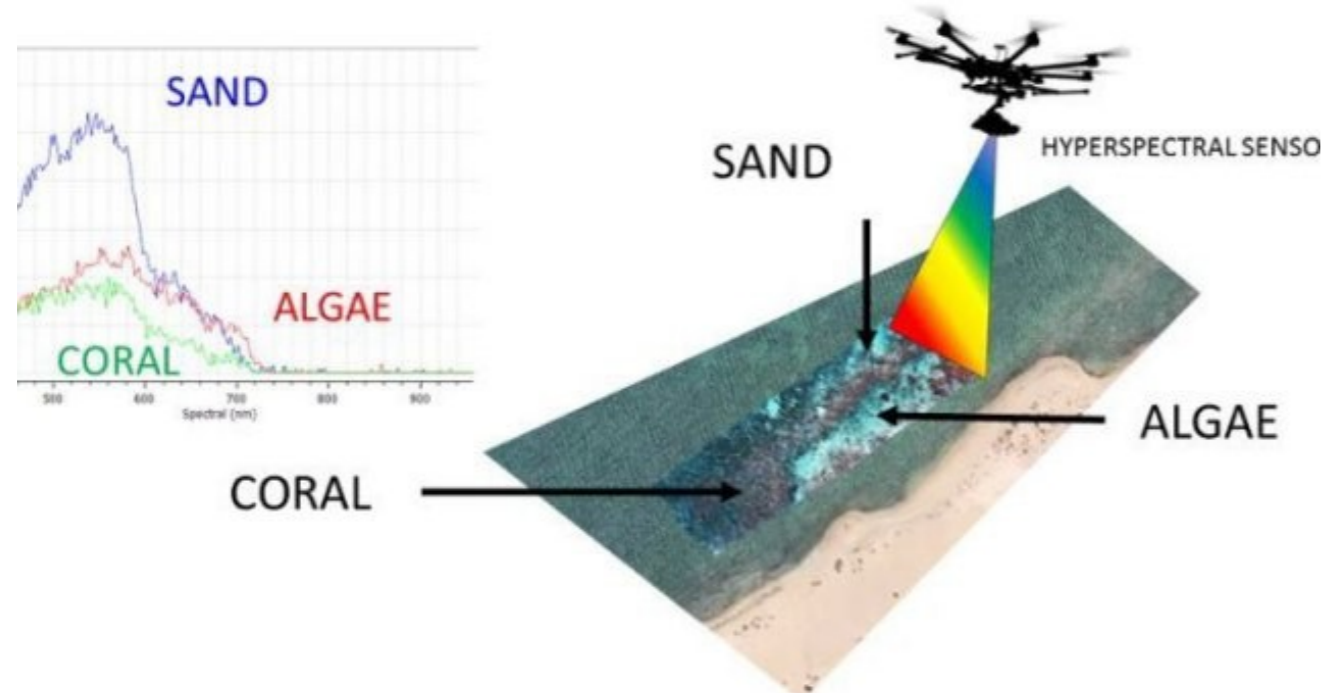
- Typical applications include:
  - Remote sensing (natural, industrial observation)
  - Safety (e.g., food and agriculture monitoring)
  - Security

- Standard scanning systems:



## Snapshot Imaging

Miniaturization for near in-situ observation (source: <http://www.abc.net.au>)



Strategies for miniaturized HSI sensors (on the left for images, middle and right for videos – Source IMEC)

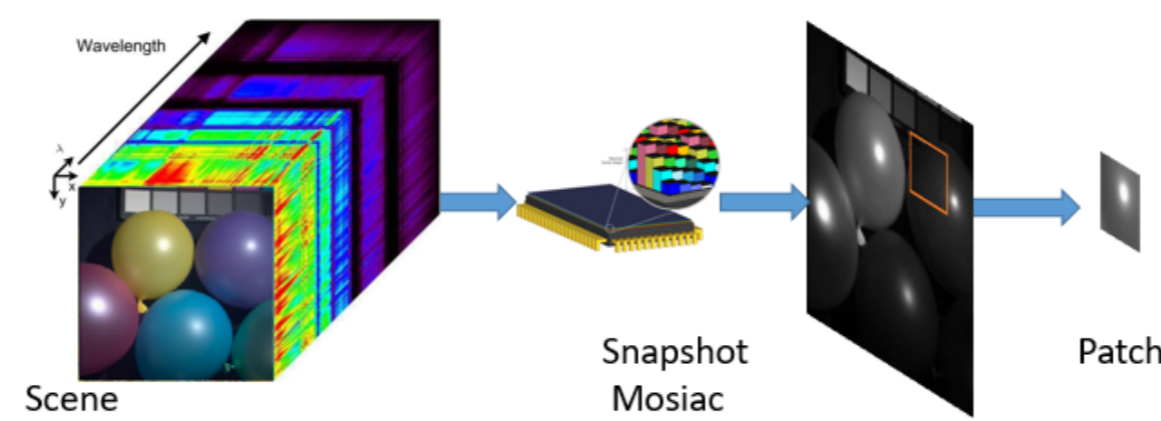


**Scanning**  
Movement needed  
**Highest spatial and spectral resolution** achievable (e.g. 100 spectral band images of 4MP x resolution today)

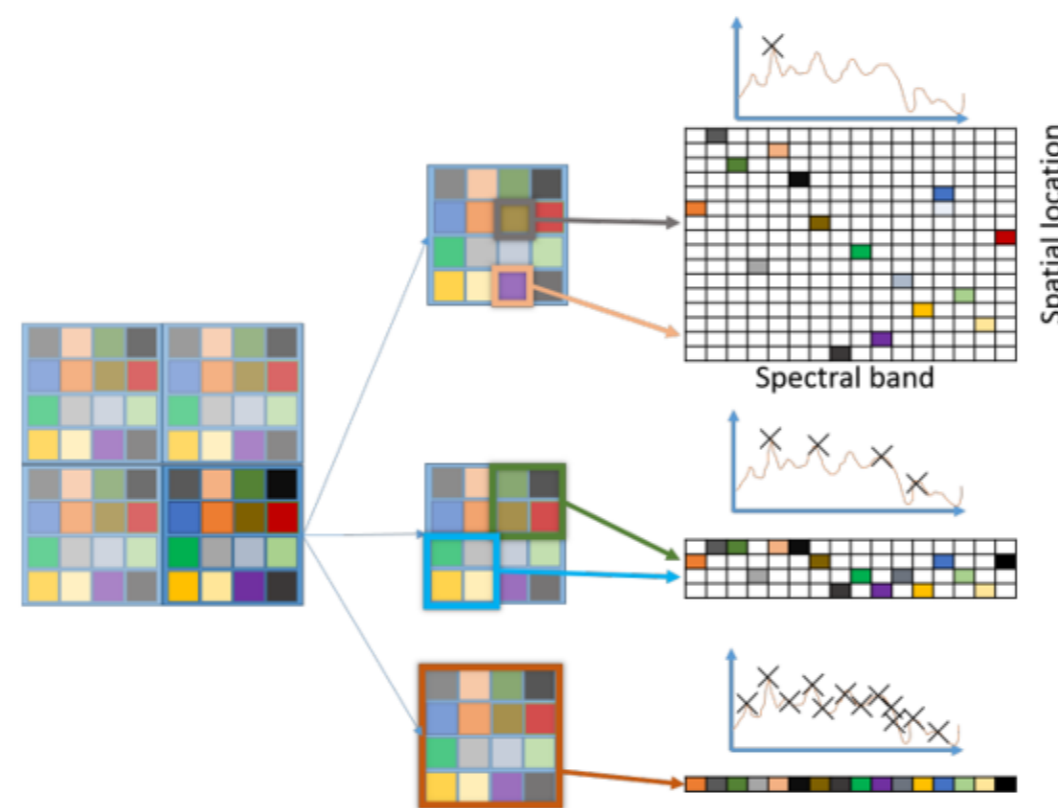
**No scan**= real-time HSI data-cubes acquisition  
Spatial vs. spectral **resolution trade-off** (e.g. 32 band images of 256x256 resolution today)  
Optical duplicator needed (e.g. lens-array today)

**No scan**= real-time HSI data-cubes acquisition  
Spatial vs. spectral **resolution trade-off** (e.g. 16 band images of 512x272 resolution today)  
Potential resolution increase by de-mosaicing algorithms

## Acquisition and Demosaicing



Principle of image acquisition by a snapshot mosaic camera

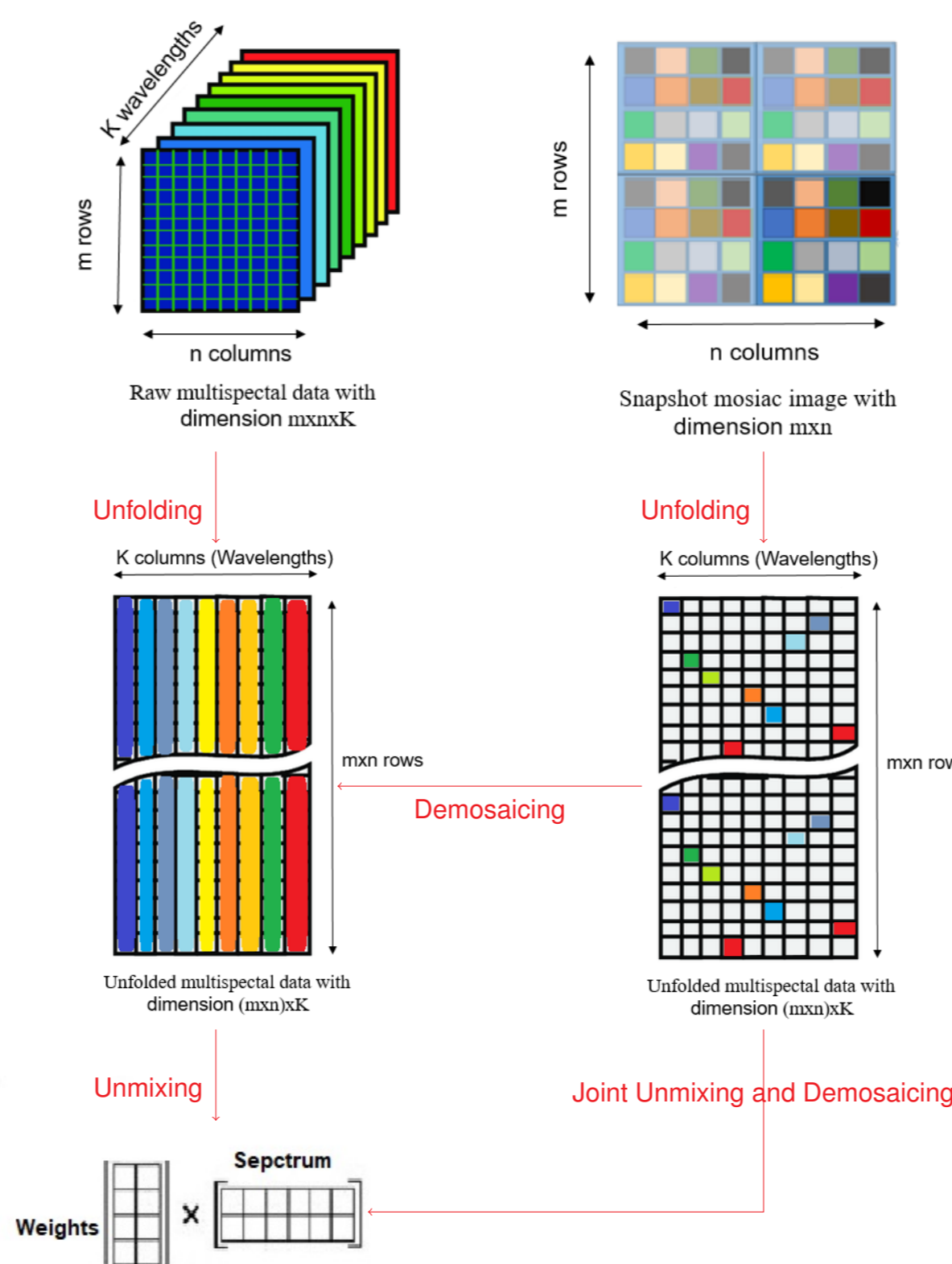


Trade-off between spectral information and spatial resolution [1]

- Demosaicing = providing a datacube combining full spectral information & good spatial resolution**
- Various approaches have been proposed:
  - Weighted bilinear interpolation (WB) [2]
  - Iterative Spectral Difference (ItsD) [3]
  - Multispectral demosaicing approach using a pseudo-panchromatic image (PPID) [4]
  - Graph and rank regularized method (GRMR) [1]

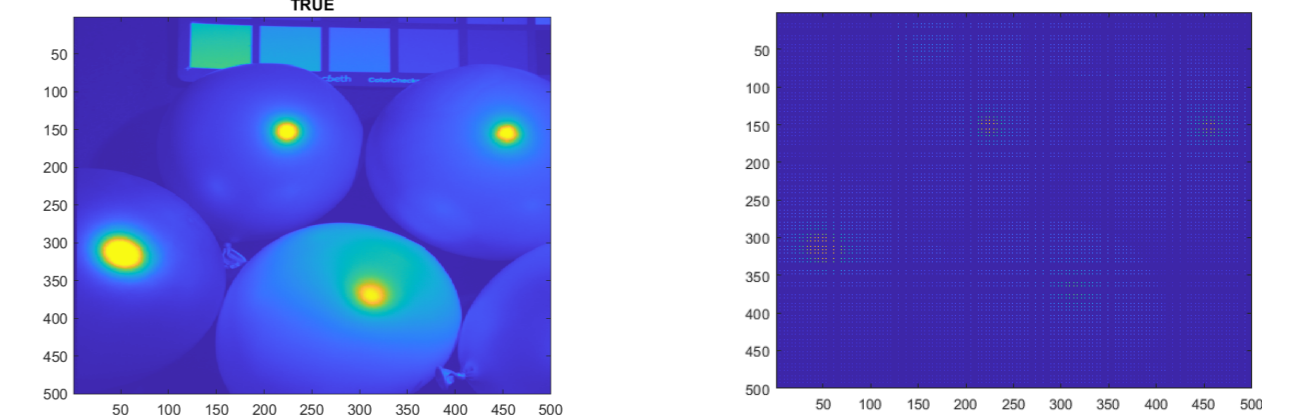
## Goal of the Ph.D. thesis

- Performing classification after demosaicing provides a poor classification performance [1]**
- In [5], **joint** low-rank matrix completion and factorization **far more accurate** than a two-stage approach (matrix factorization after low-rank matrix completion)
- Joint Demosaicing and Unmixing more efficient than a two-stage approach?**
  - Ph.D. thesis started in June 2021
  - Weighted NMF tested to perform joint unmixing and demosaicing
  - Proposed approach based on Expectation-Maximization framework and inspired by [6]



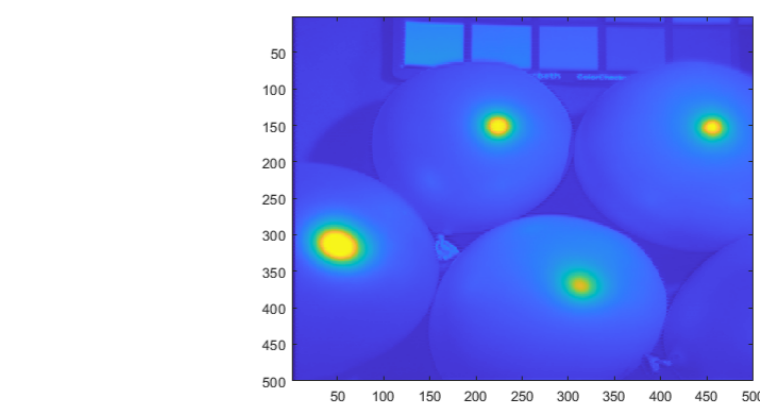
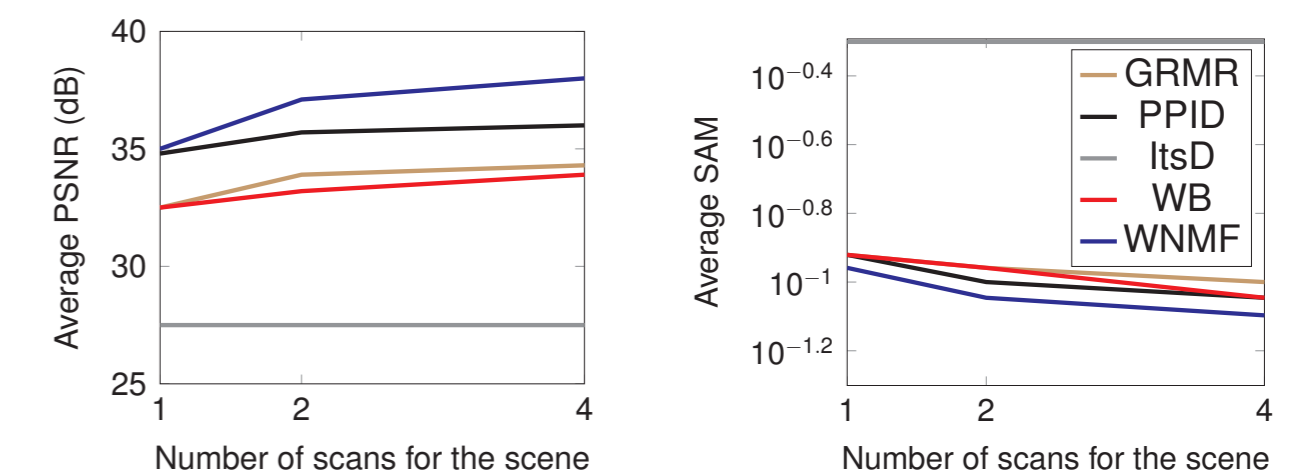
## Experiment and results

- To validate the performance of the proposed approach, we conducted an experiment on CAVE dataset.
- We assume that the hyperspectral imagery in CAVE is acquired using a SSI camera system, equipped with a  $4 \times 4$  spectral filter pattern.
- Simulations assuming an ideal snapshot mosaic filter



Left: original HSI to estimate. Right: observed image.

- Reconstruction quality is measured in terms of Peak Signal-to-Noise Ratio (PSNR, in dB) and of average Spectral Angle Map (SAM) metric.



Estimated image from the above example, using WNMF

## Conclusion and Future Work

- Start of the Ph.D. thesis
- WNMF already provides better demosaicing performance than tested SotA methods
- Next steps:
  - Evaluate WNMF performance for unmixing
  - Apply the proposed method on real data acquired by an SSI camera

## References and Acknowledgments

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