

UNIVERSITY OF TWENTE.

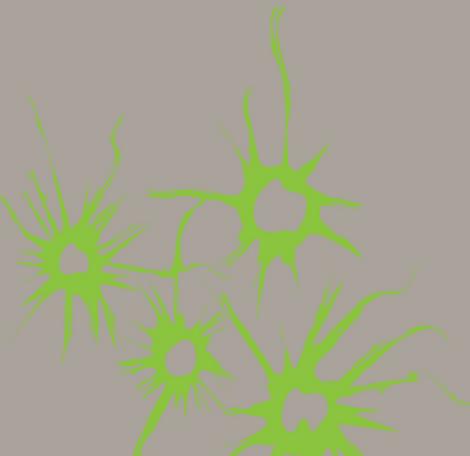
Remote Sensing Image Classification

Mahdi KHODADADZADEH

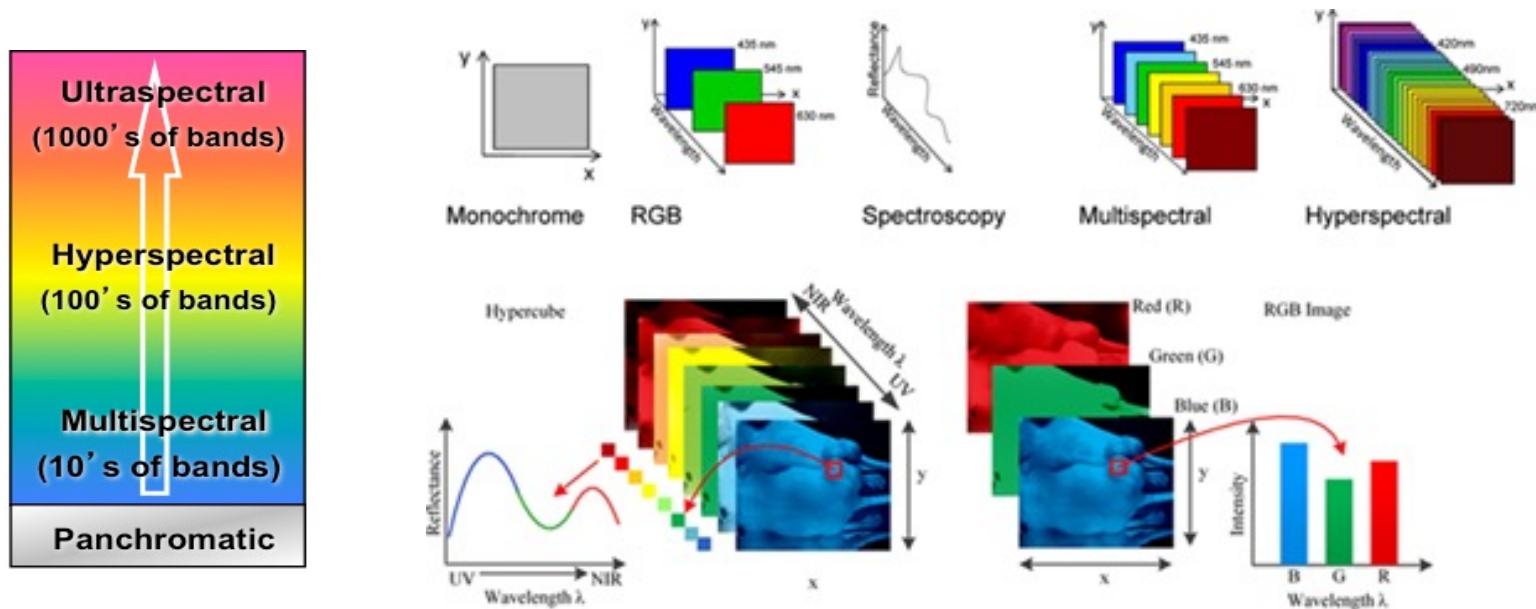
October 2021



FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION



Imaging, Spectroscopy and Imaging Spectroscopy



From: Mehta N, Shaik S, Devireddy R, Gartia M. Single-Cell Analysis Using Hyperspectral Imaging Modalities. ASME. J Biomech Eng. 2018;140(2):020802-020802-16.

Hyperspectral images

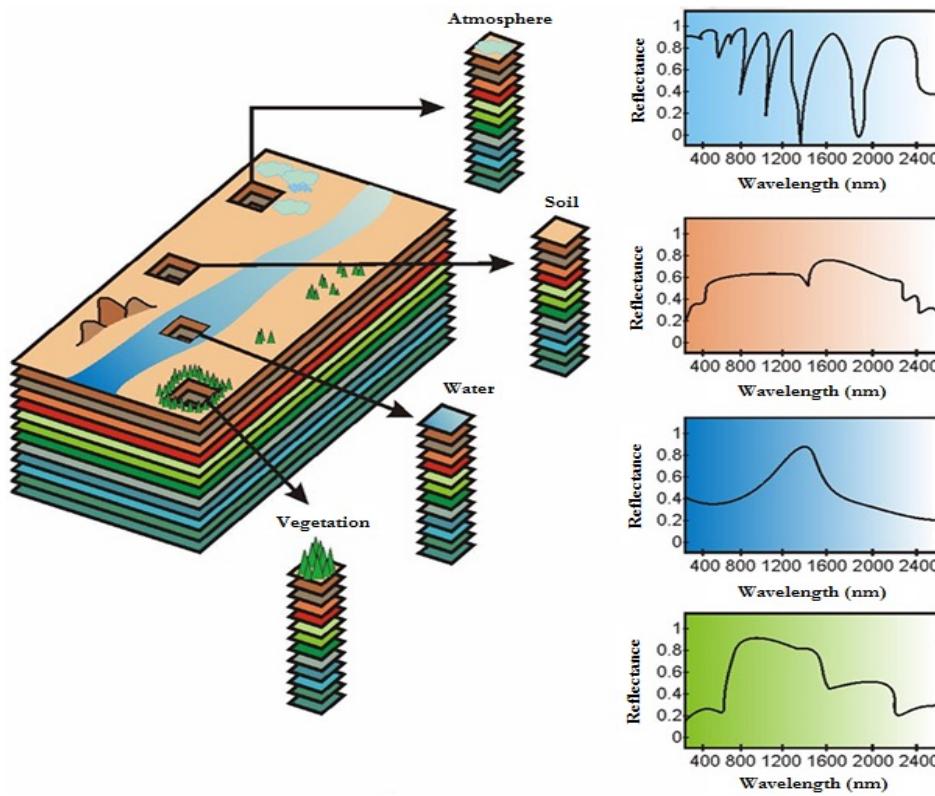
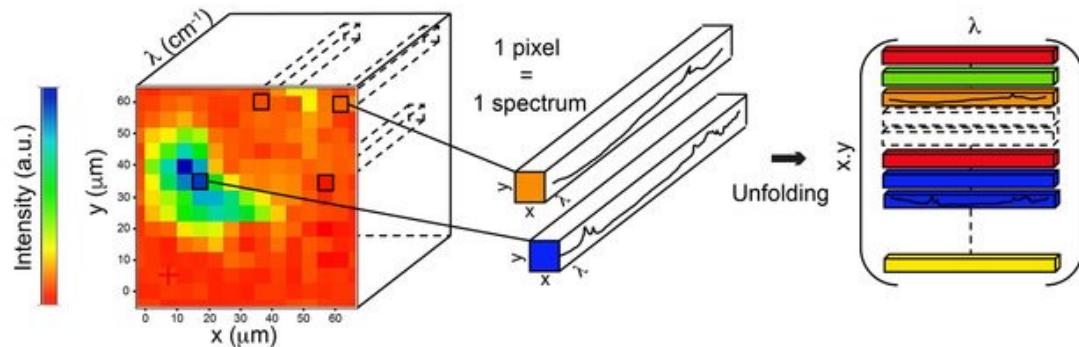
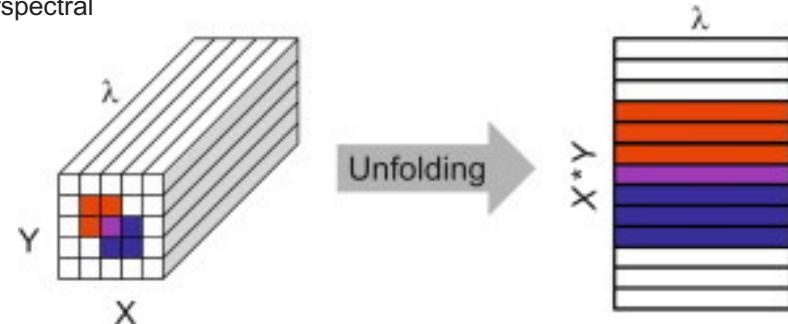


Image Unfolding

→ 2D matrix format



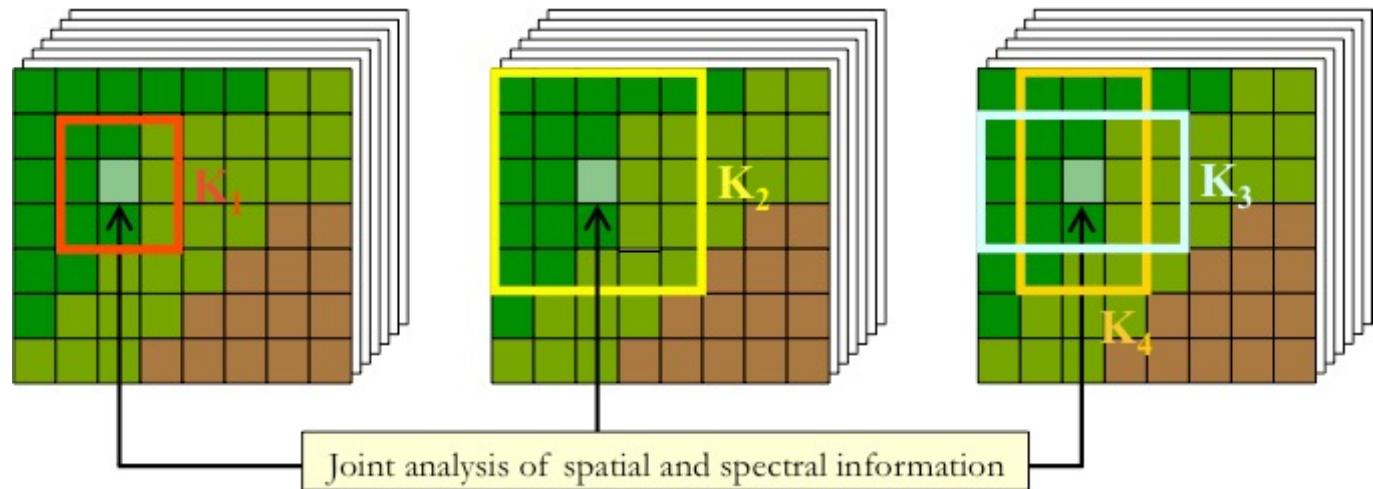
From: Pisapia, C., Jamme, F., Duponchel, L. and Ménez, B., 2018. Tracking hidden organic carbon in rocks using chemometrics and hyperspectral imaging. *Scientific reports*, 8(1), pp.1-14.



From: Amigo, J.M., Martí, I. and Gowen, A., 2013. Hyperspectral imaging and chemometrics: a perfect combination for the analysis of food structure, composition and quality. In *Data handling in science and technology* (Vol. 28, pp. 343-370). Elsevier.

The importance of spatial information

- There is a need to integrate the spatial and spectral information to take advantage of the complementarities that both sources of information can provide.



The importance of spatial information

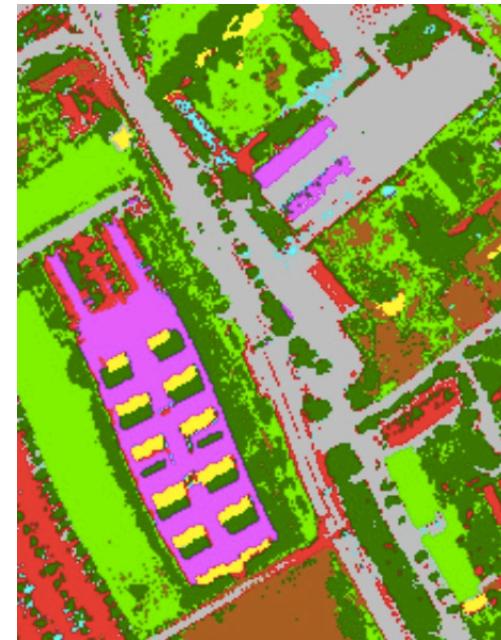
- When dealing with remote sensing images with high spatial resolution, the use of spatial information can increase the discrimination of the thematic classes.
- Spectral-spatial classification can lead to significantly more accurate results



True color image



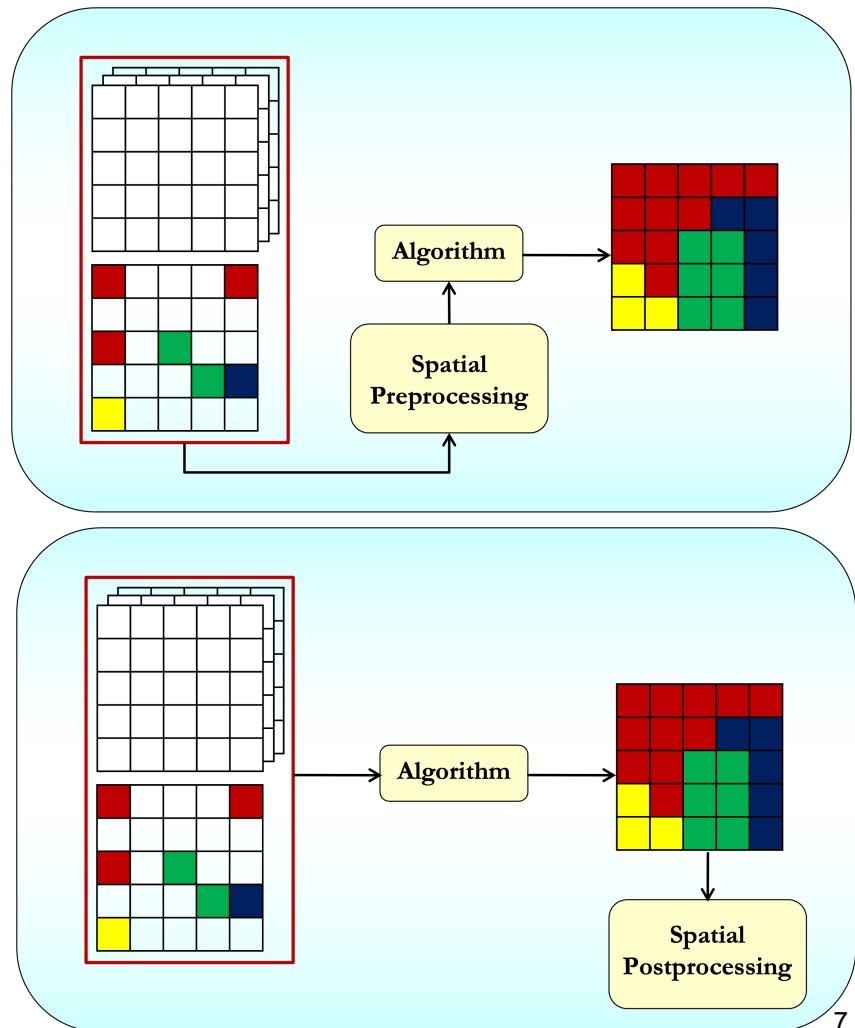
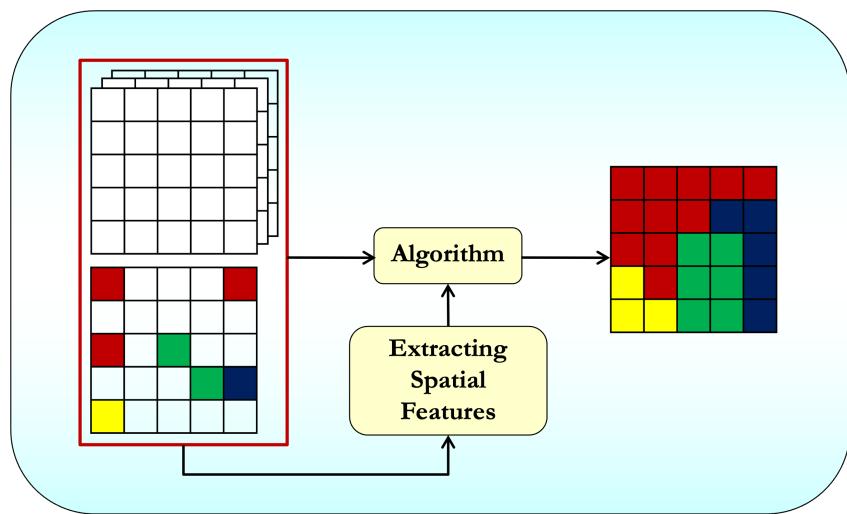
Spectral classification



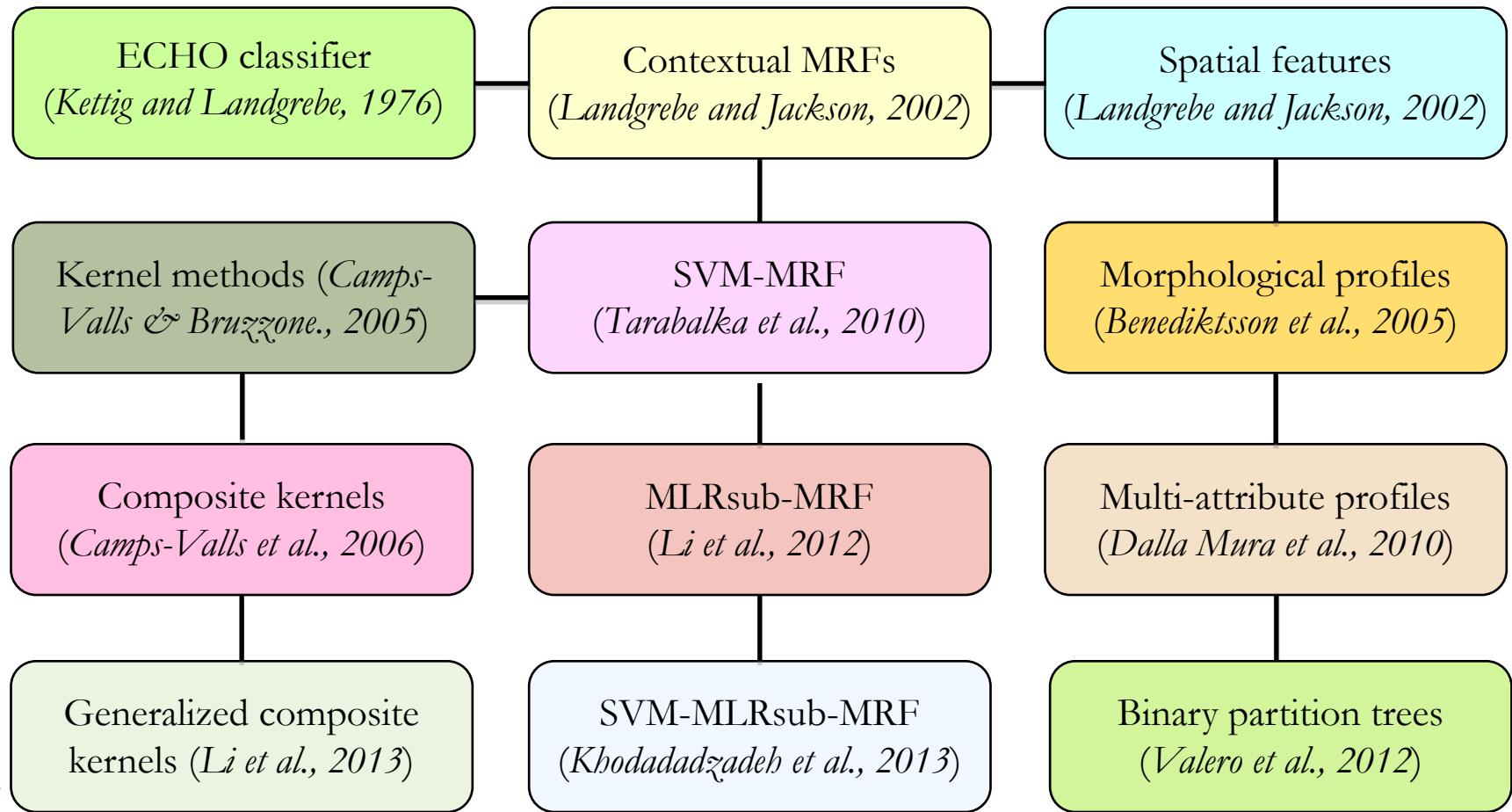
Spectral-spatial classification

Spectral-spatial approaches

- Spatial pre-processing
- Spectral-spatial feature learning
- Spatial post-processing



Traditional spectral-spatial approaches



Advanced spectral-spatial approaches

- Deep Learning

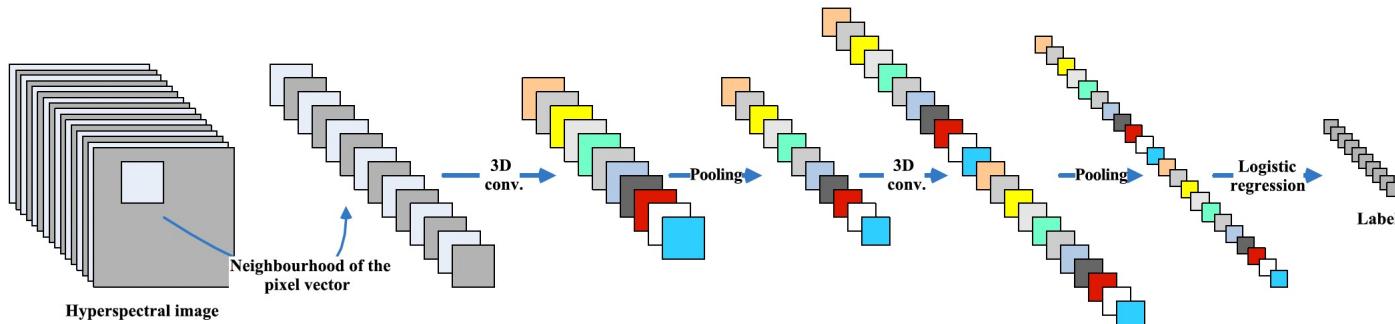


Fig. 6. Architecture of 3-D CNN with spectral–spatial features for HSI classification.

Chen, Y., Jiang, H., Li, C., Jia, X. and Ghamisi, P., 2016. Deep feature extraction and classification of hyperspectral images based on convolutional neural networks. *IEEE Transactions on Geoscience and Remote Sensing*, 54(10), pp.6232-6251.

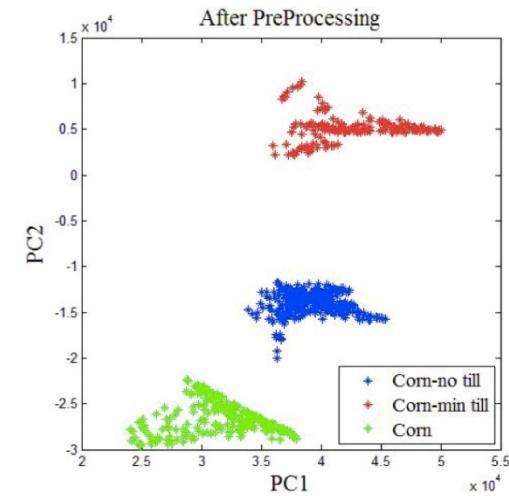
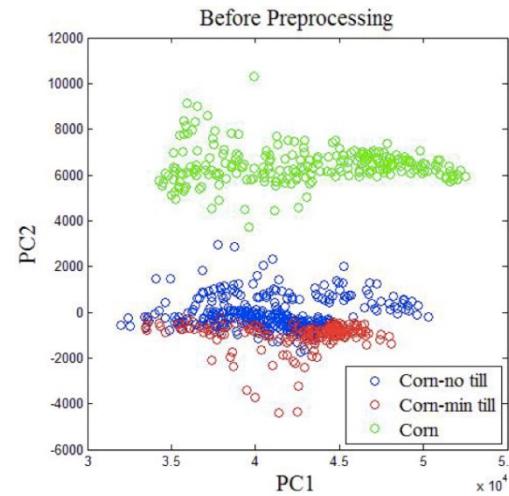
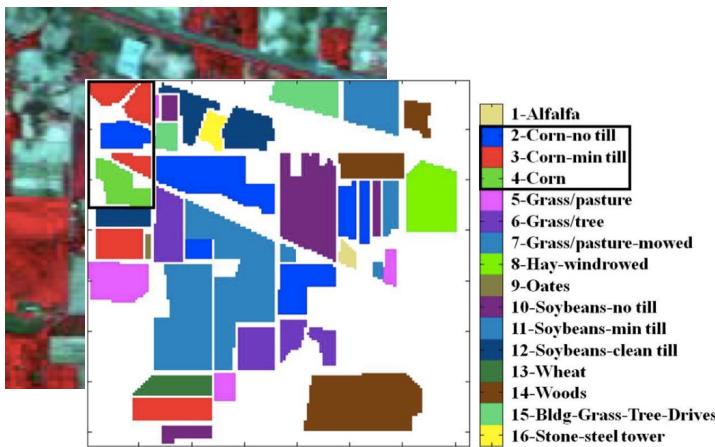
Spatial pre-processing

- A simple lowpass filter to increase class separability and classification accuracies



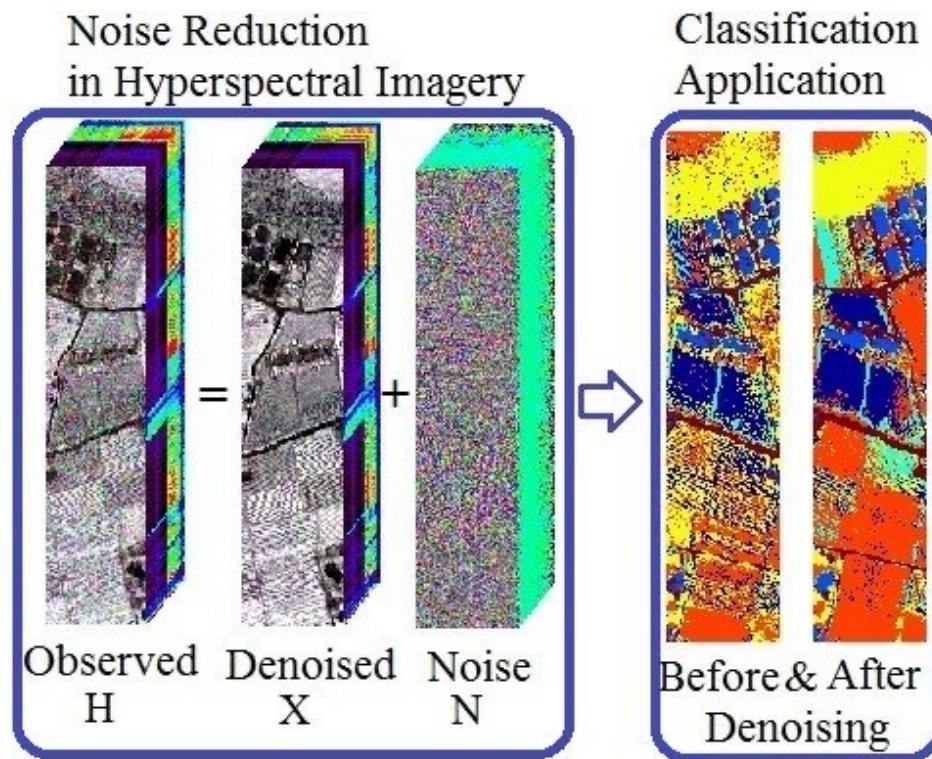
Spatial pre-processing

- Before extracting features from the hyperspectral image, we first conduct a preprocessing which introduces information from neighborhood of each pixel
- A simple lowpass filter to increase class separability and classification accuracies



Spatial pre-processing

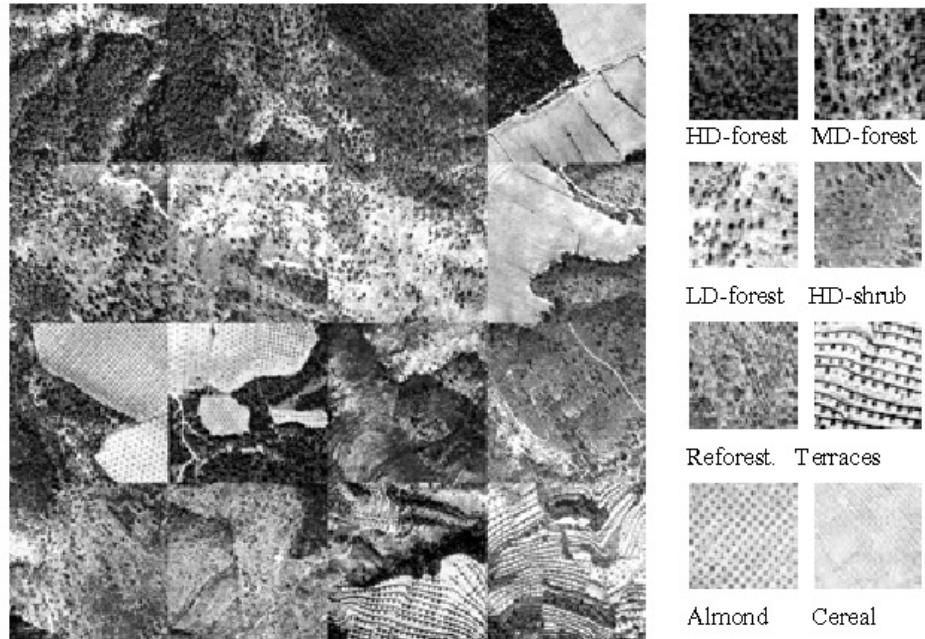
- Image denoising



Rasti, B., Scheunders, P., Ghamisi, P., Licciardi, G. and Chanussot, J., 2018. Noise reduction in hyperspectral imagery: Overview and application. *Remote Sensing*, 10(3), p.482.

Spatial feature extraction

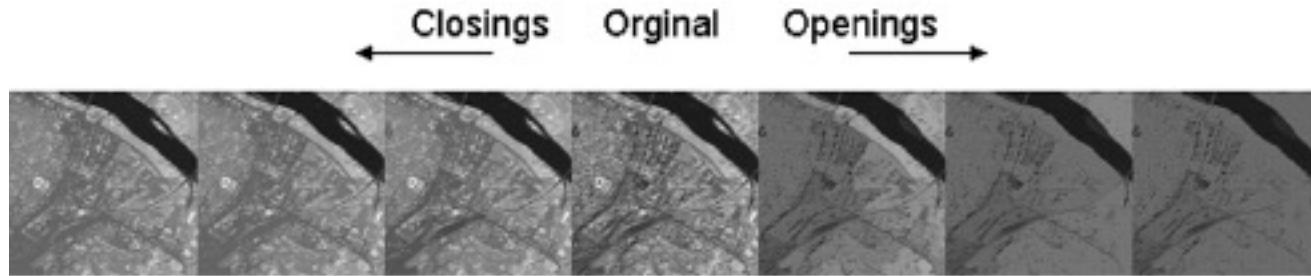
- Texture feature extraction



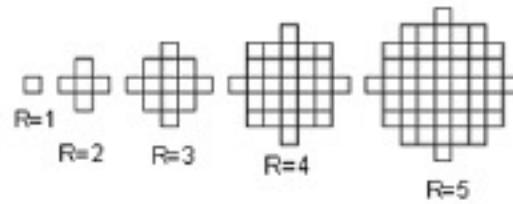
Ruiz, L.A., Fdez-Sarria, A. and Recio, J.A., 2004, July. Texture feature extraction for classification of remote sensing data using wavelet decomposition: A comparative study. In *20th ISPRS Congress* (Vol. 35, No. part B, pp. 1109-1114).

Spatial feature extraction

- Morphological feature extraction

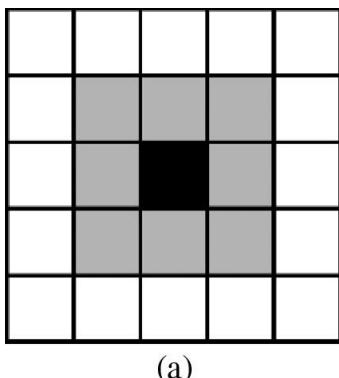


- Structuring Element: disc
- Segmentation Variables
 - Number of openings/closings
 - Radius increment (step size)



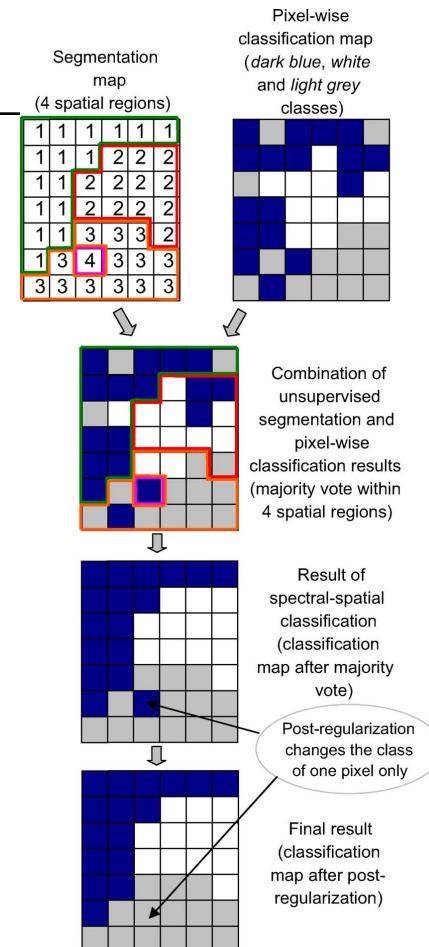
Spatial post-processing

- Majority Voting



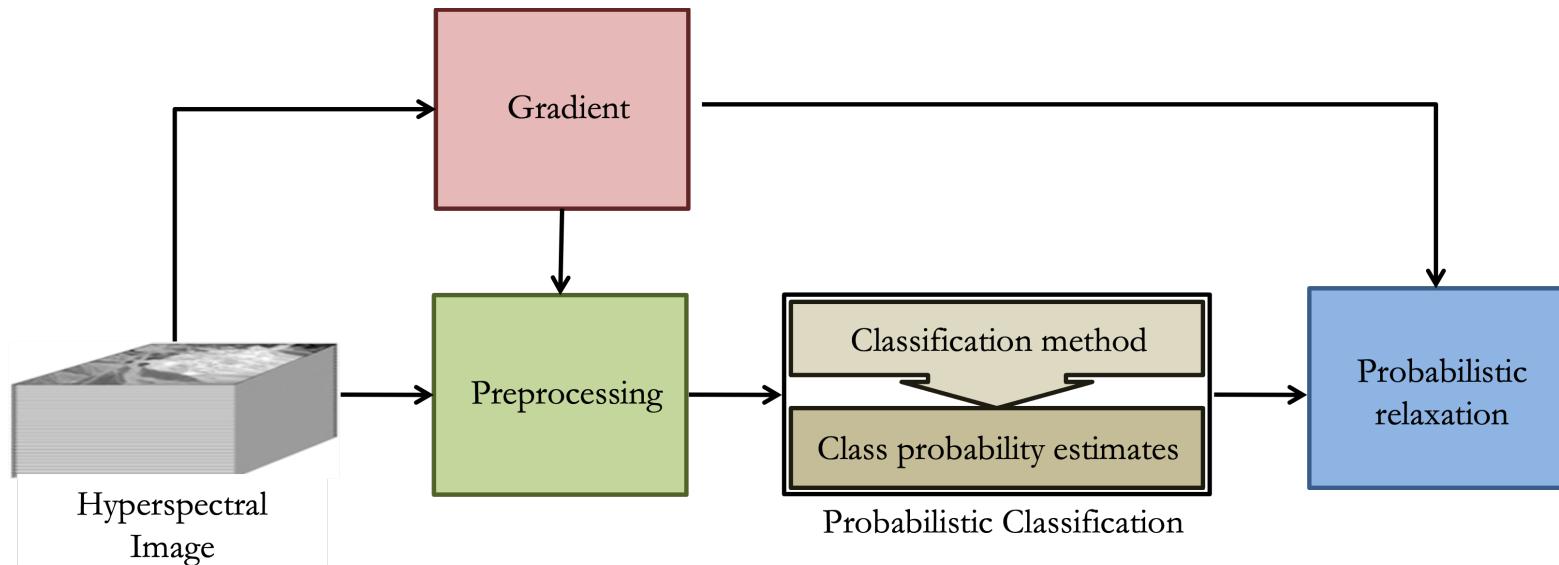
Neighborhoods (in gray) for a black pixel:
(a) 8 neighbors and (b) 16 neighbors.

Tarabalka, Y., Benediktsson, J.A. and Chanussot, J., 2009. Spectral-spatial classification of hyperspectral imagery based on partitional clustering techniques. *IEEE transactions on geoscience and remote sensing*, 47(8), pp.2973-2987.



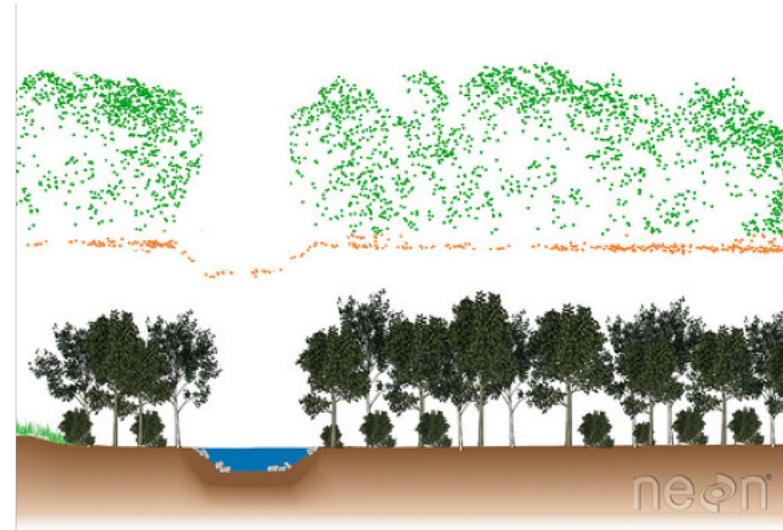
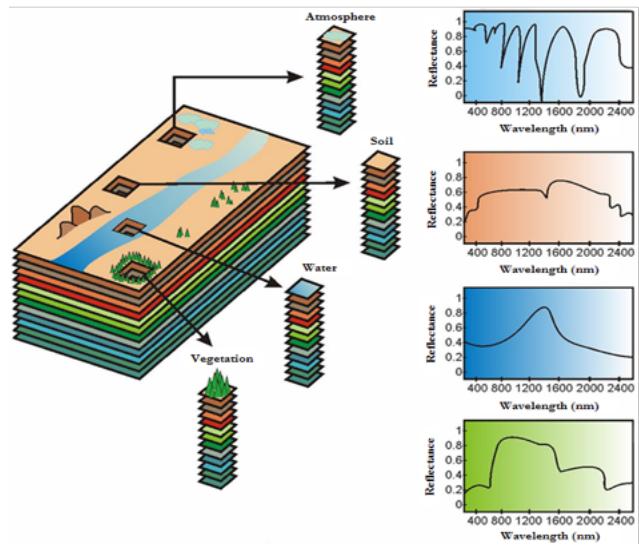
Discontinuity Preserving Relaxation

- Improves the classification accuracy in smooth image areas



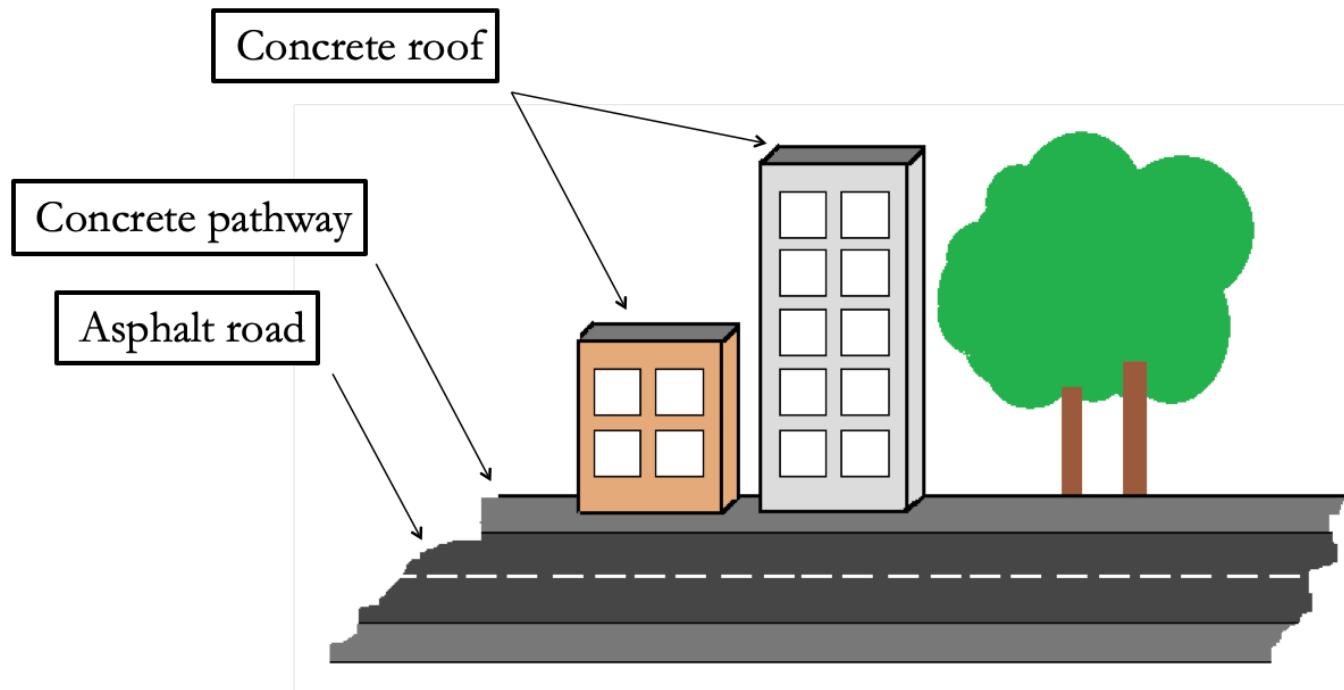
Hyperspectral and LiDAR

- Hyperspectral sensors provide rich spectral information for distinguishing different materials.
- LiDAR can provide information on 3D geometry (the elevation of the Earth's surface and objects on the landscape).
- Combining information from multiple sources is an effective way to improve classification results.



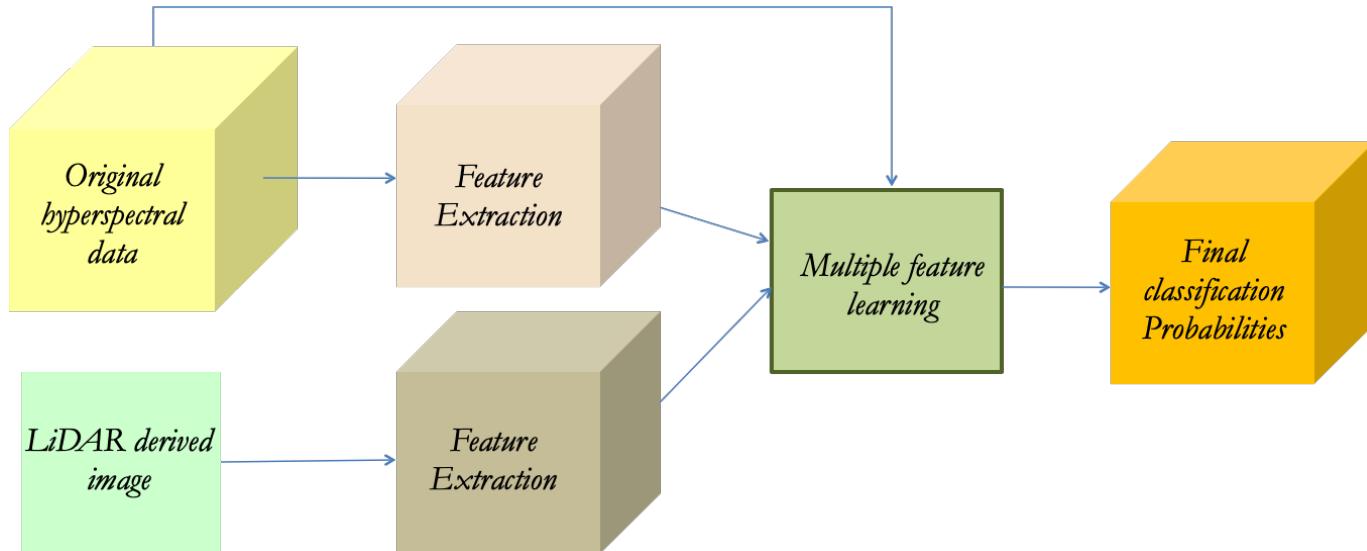
Hyperspectral and LiDAR

- The information provided by LiDAR can effectively complement the spectral information from the hyperspectral data for classification purposes



Hyperspectral and LiDAR

- Fusion of hyperspectral and LiDAR data



Khodadadzadeh, M., Li, J., Prasad, S. and Plaza, A., 2015.
Fusion of hyperspectral and LiDAR remote sensing data using
multiple feature learning. *IEEE Journal of Selected Topics in
Applied Earth Observations and Remote Sensing*, 8(6), pp.2971-
2983.