Supervised Classification of Hyperspectral Images using Side Information

Karen Sánchez, Carlos Hinojosa, Henry Arguello

Computational Optical Sensing and Imaging

High Dimensional Signal Processing Research Group

Universidad Industrial de Santander

June 27, 2018

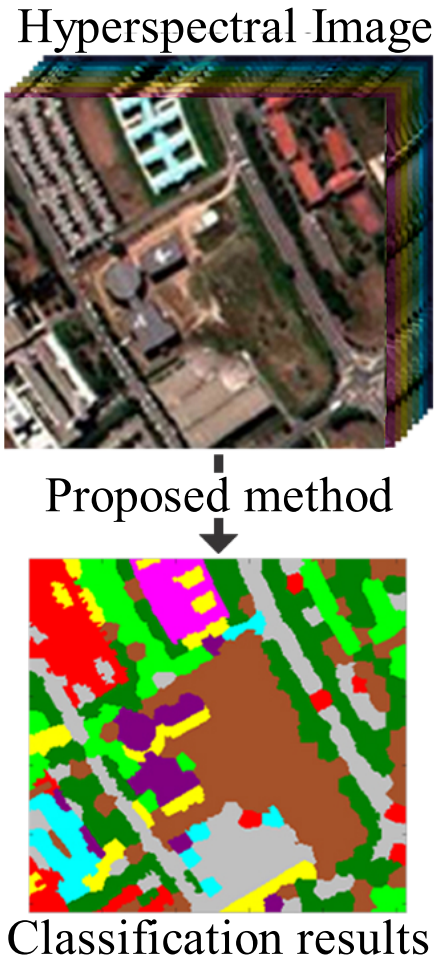
OSA Imaging and Applied Optics Congress

High-Dimensional Signal Processing Research Group
www.hdspgroup.com

Universidad Industrial de Santander

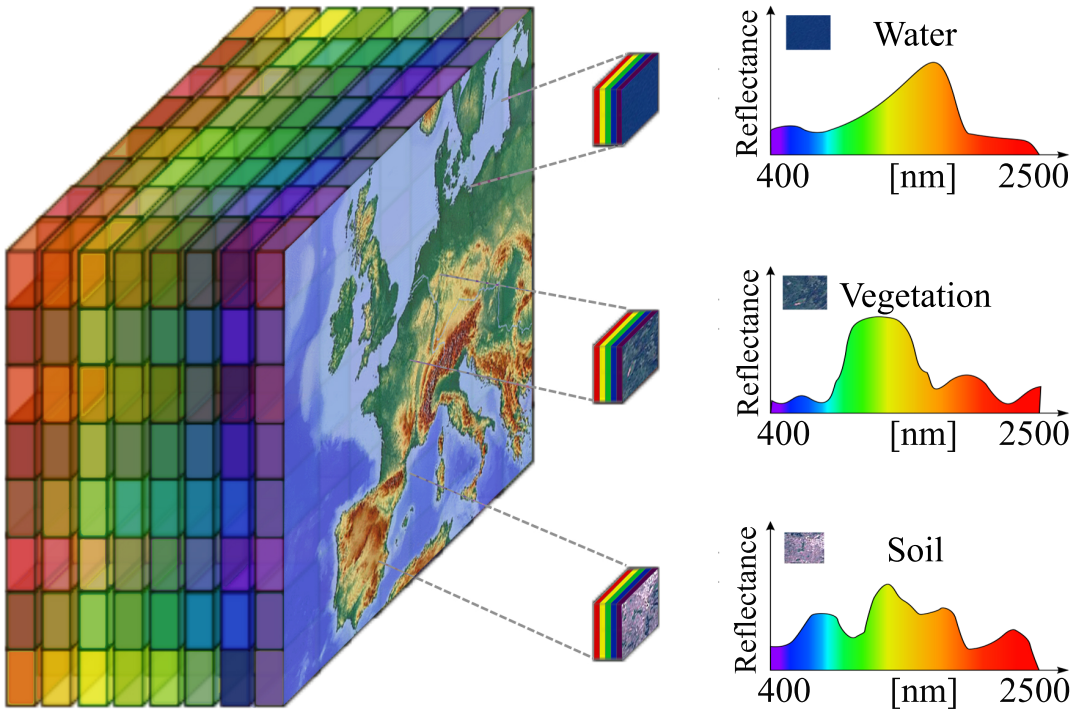
Outline

1. **INTRODUCTION**
   - 1.1 **Hyperspectral Imaging (HS)**
2. **PROPOSED METHOD**
   - 2.1 **Superpixels segmentation**
   - 2.2 **Multi-resolution Image Fusion**
   - 2.3 **Classification**
3. **SIMULATIONS AND RESULTS**



Hyperspectral Imaging (HSI)

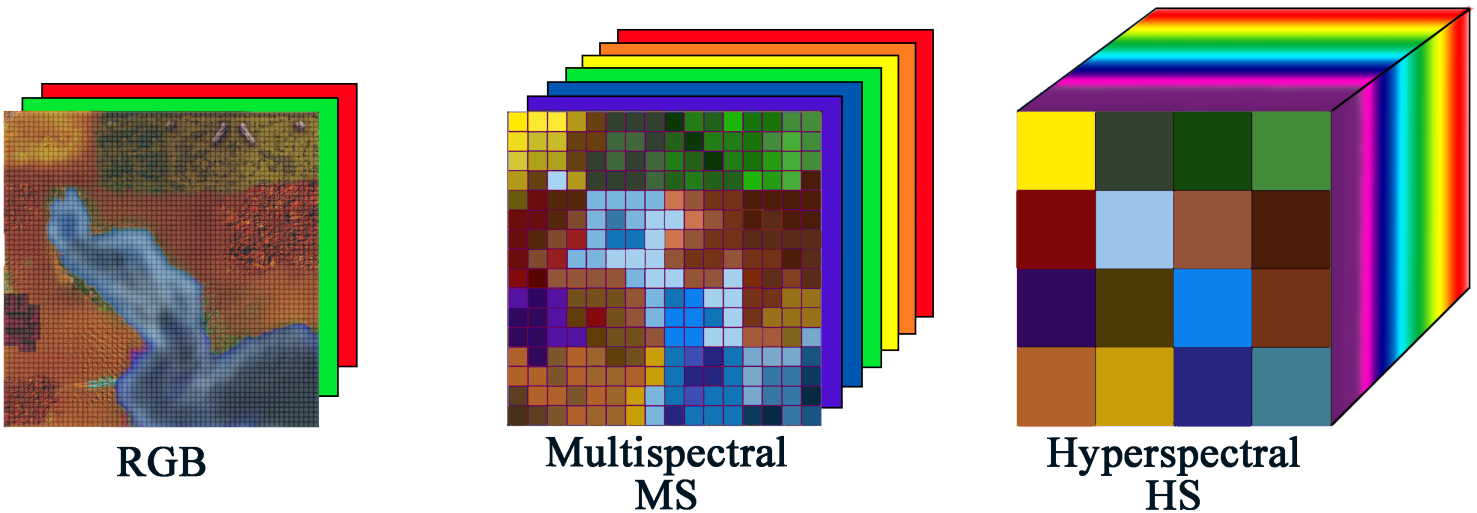
- Spatial information at different wavelengths. Provide an individual spectral signature for each pixel in the image.



- These images are used for classification in areas such as biomedical imaging, food quality, artwork conservation, etc.

Hyperspectral Imaging (HSI)

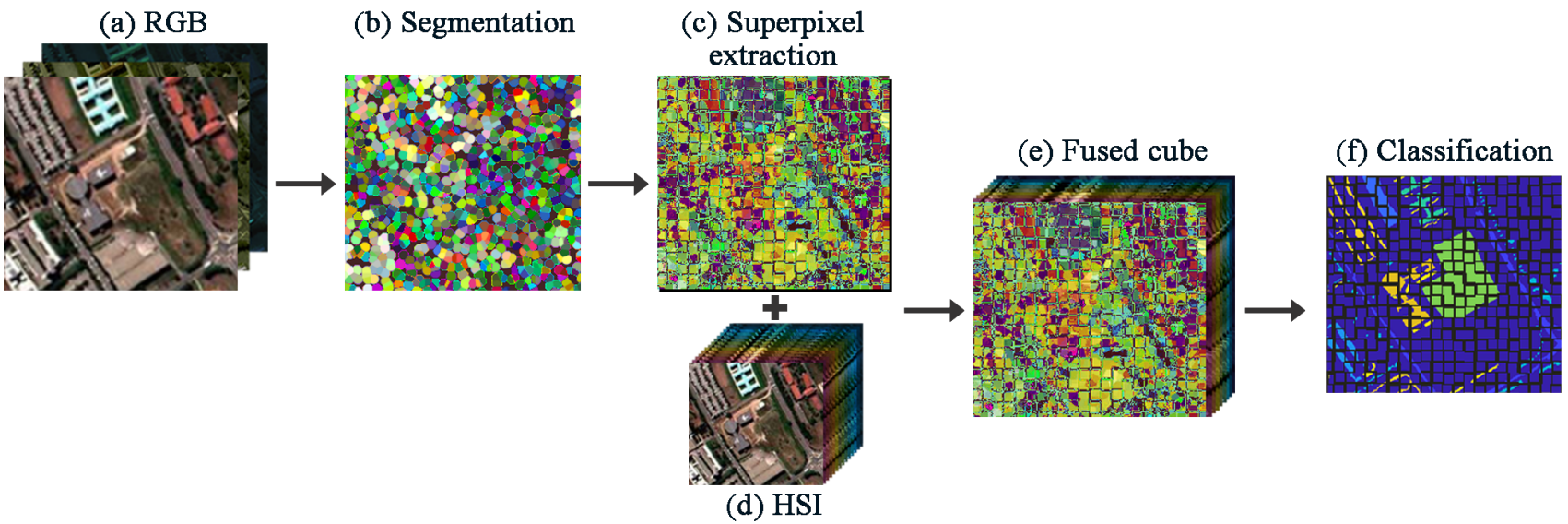
- **Limitation:** For storage reasons, the hyperspectal images provide rich spectral information, but low spatial resolution.



- Lower resolutions difficult to obtain an accurate classification.

The Proposed Method

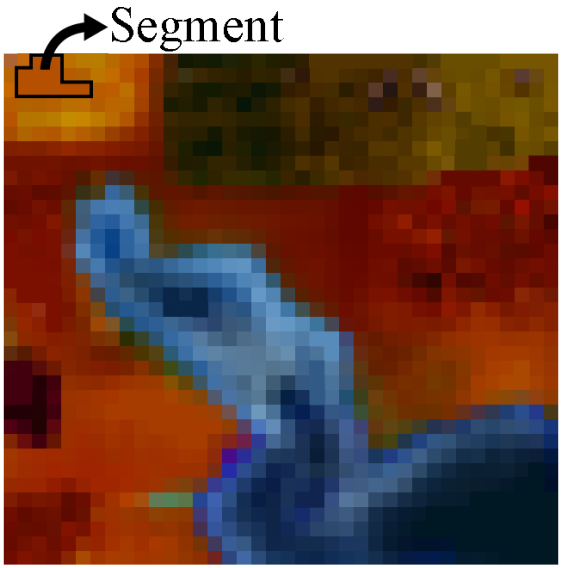
- **Proposed solution:** A method for HSI classification with an RGB image as side information segmented in superpixels.



Flowchart of the global method proposed.

The Proposed Method: Superpixels

- **Superpixels**:
  - First, the SLIC[1] superpixels algorithm runs over the RGB image where the number of desired segments N_{seg} is specified.



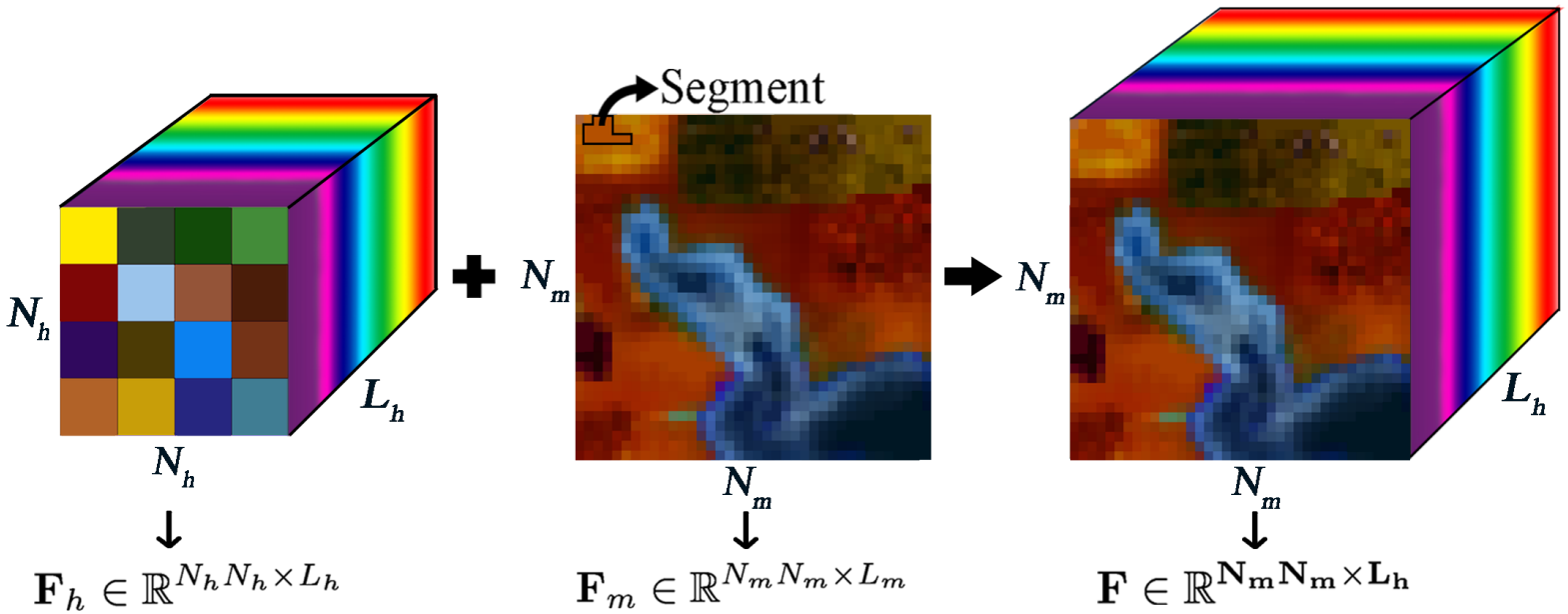
RGB + superpixels
$N_{seg} = 500$

- RGB image: Higher spatial resolution.
- Group spatial information that matches.
- To reduce the number of pixels that should be classified.

[1] Achanta, R. et al. SLIC superpixels compared to state-of-the-art superpixel methods.IEEE Trans. Pattern Anal. Mach. Intell. 2012, vol. 34, no 11, p. 2274 – 2282.

The Proposed Method: Multi-resolution Image Fusion

- A rich spatial and spectral fused cube with superpixel information extracted from the RGB image is obtained.

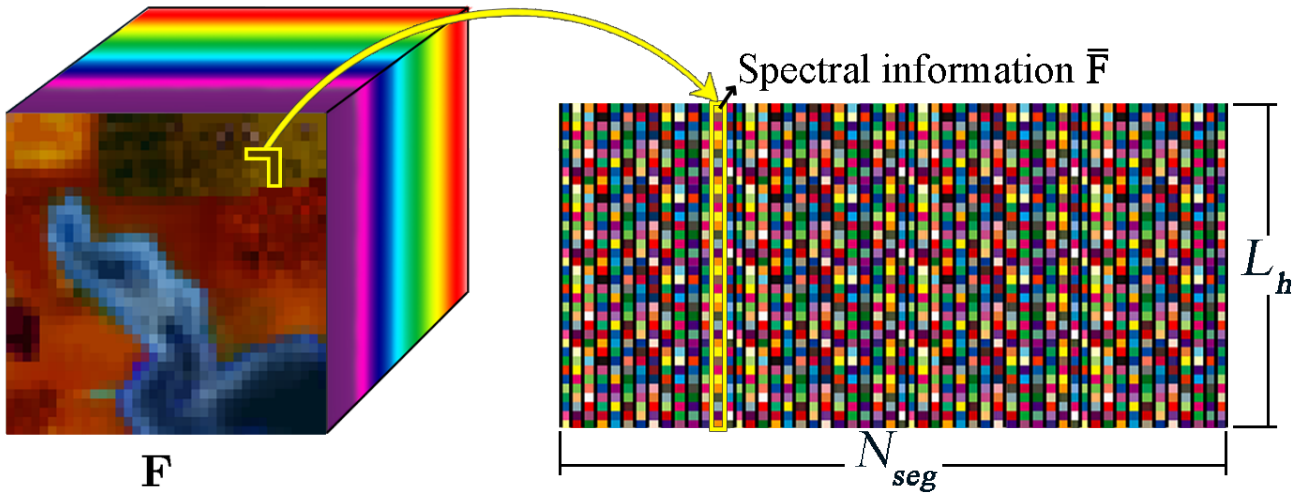


- The optimization problem can be formulated as:

$$\min_{\mathbf{F}} \frac{1}{2} \|\mathbf{F}_h - \mathbf{D}_m \mathbf{F}\|_F^2 + \lambda \|\mathbf{F}\|_* \qquad (1)$$

The Proposed Method: Multi-resolution Image Fusion

- The matrix $\bar{\mathbf{F}} \in \mathbb{R}^{Nseg \times L_h}$ is shown:



- $\mathbf{U_w}^T \in \mathbb{R}^{N_m N_m \times N_{seg}}$ is an upsampling matrix operator, such that $\mathbf{F} = \mathbf{U_w}^T \bar{\mathbf{F}}$, and $\mathbf{D}_m \in \mathbb{R}^{N_h N_h \times N_m N_m}$ is a downsampling matrix operator. The **Proposed method** is:

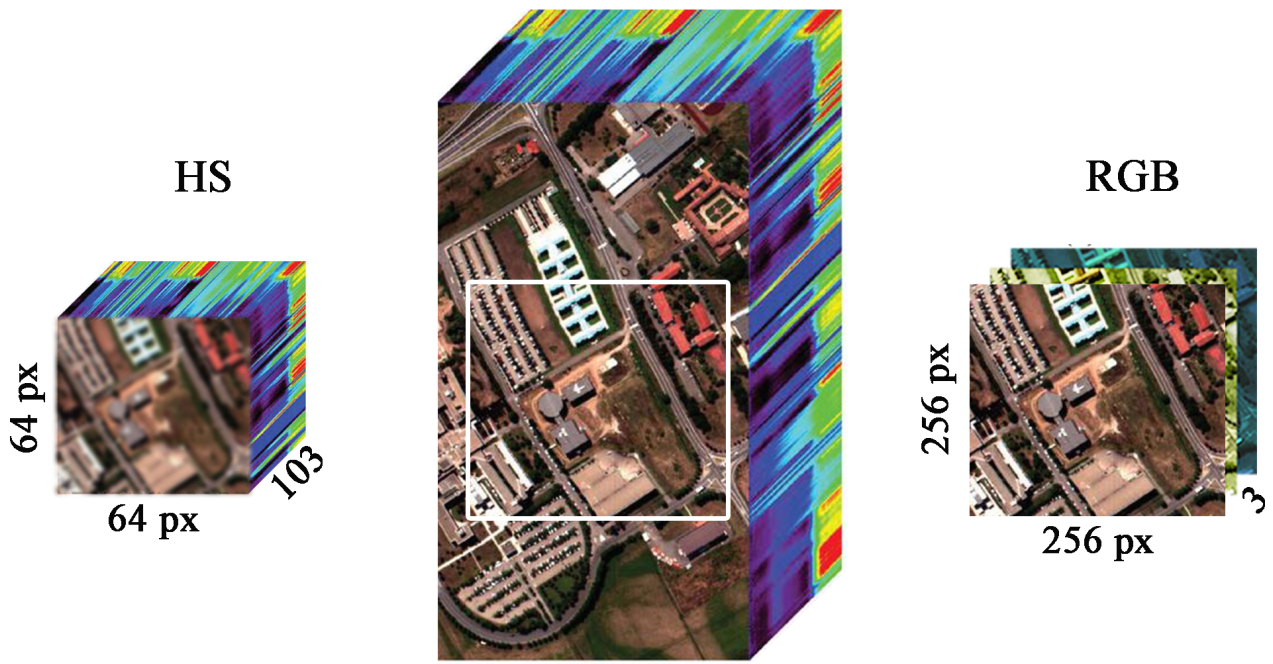
$$\min_{\bar{\mathbf{F}}} \frac{1}{2} \|\mathbf{F}_h - \mathbf{D}_m \mathbf{U_w}^T \bar{\mathbf{F}}\|_F^2 + \lambda \|\bar{\mathbf{F}}\|_*. \qquad (2)$$

The Proposed Method: Classification

- The classification of the spectral scene is achieved using a k-nearest neighbor classifier which was trained using a specific number of samples from **F**.

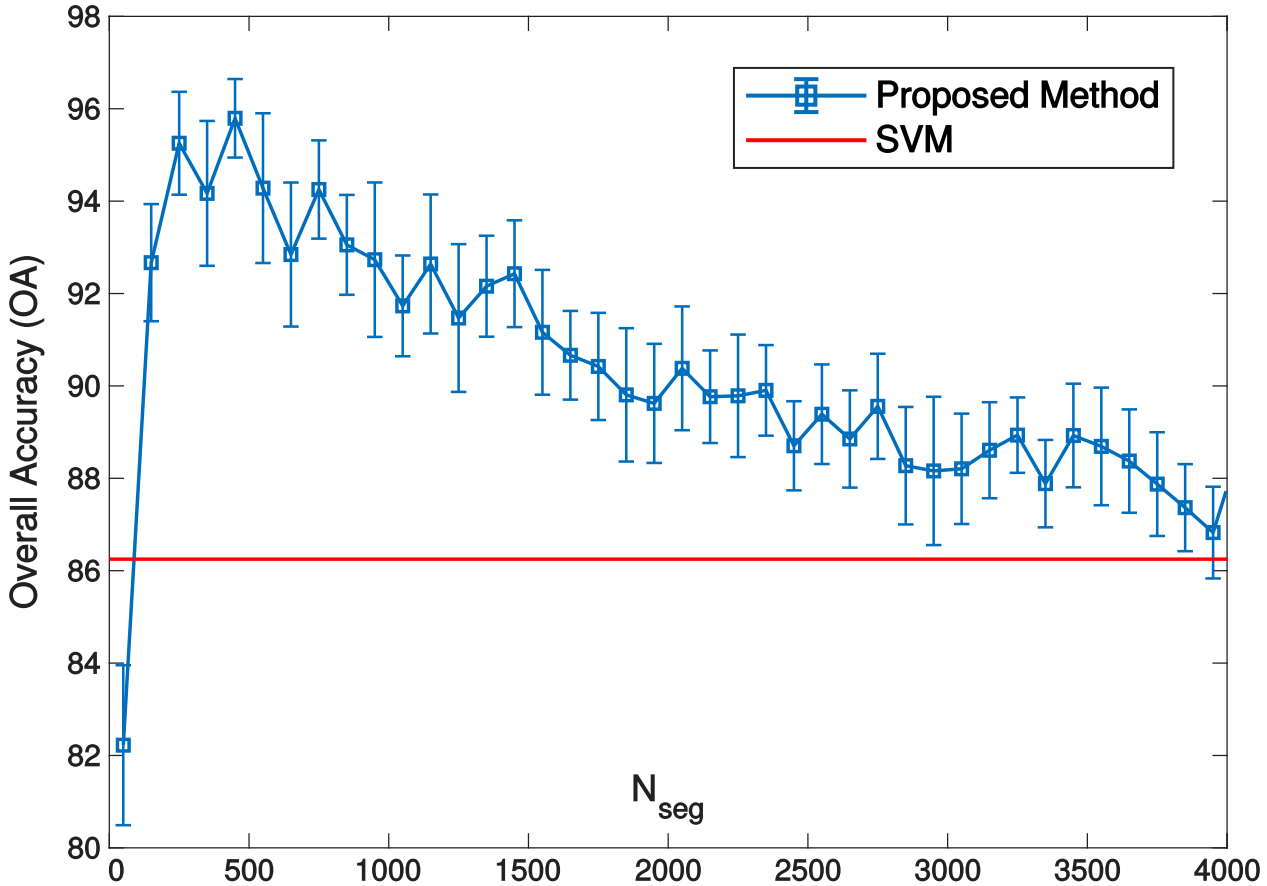
Simulations and Results

- Dataset: A region of the ROSIS Pavia University dataset that includes **nine** land-cover classes.
  - Training: 50 random samples for each class.
  - 25 realizations.



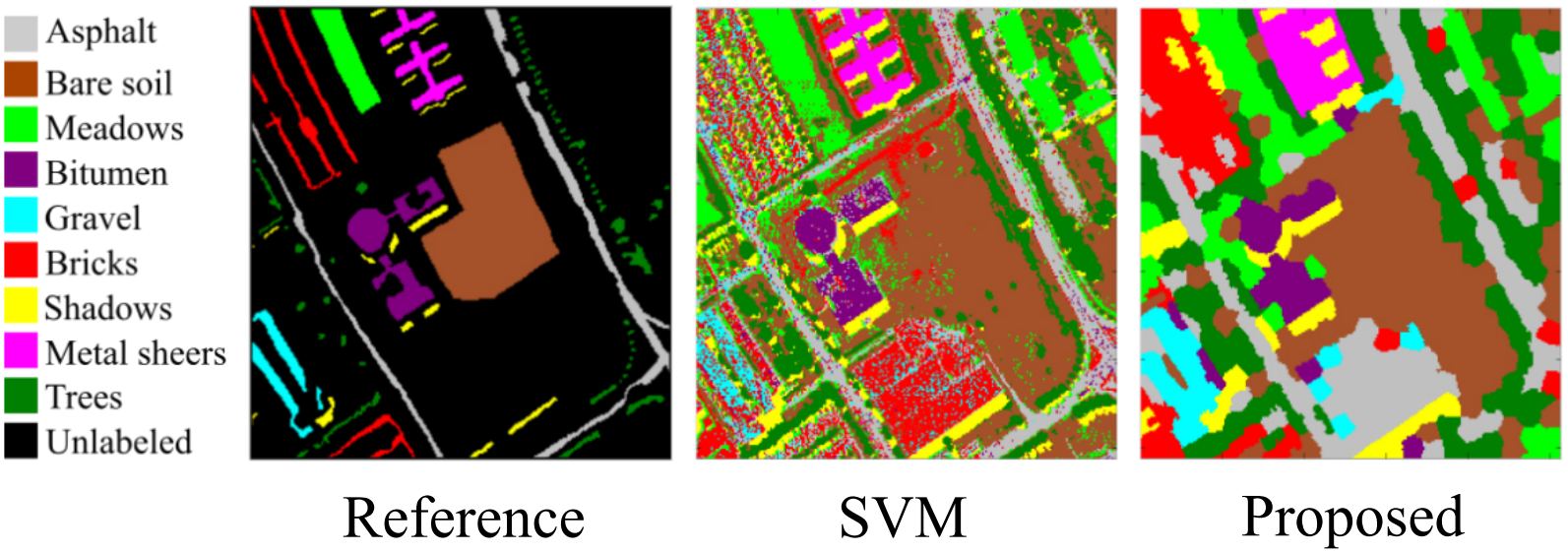
Simulations and Results

- Overall accuracy of classification for the proposed method varying the number of segments (N_{seg}) in the superpixel algorithm.



Simulations and Results

- In the figure:
  - $\mathbf{N}_{seg}$ = 450 superpixels.
  - Proposed approach vs. the support vector machine (SVM) classifier.



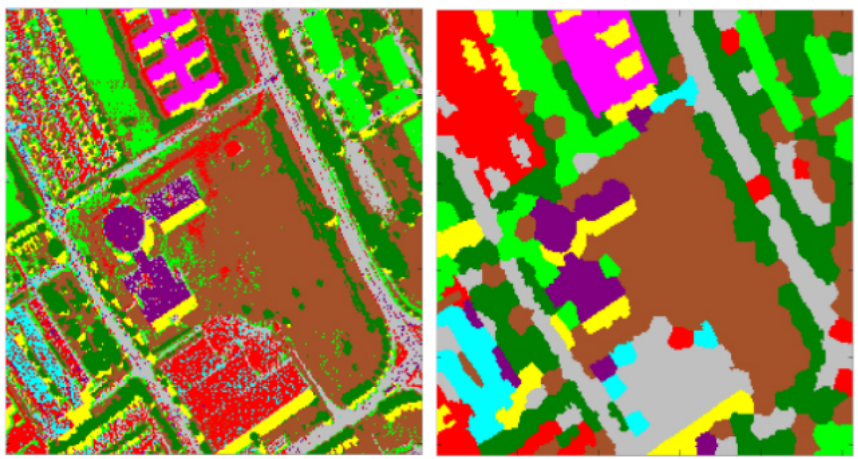
Simulations and quantitative results

Quantitative classification metrics comparison between different methods for the Pavia Image.

	Accuracy	
Class	**SVM classifier**	**Proposed method**
Asphalt	81.33 %	**82.23 %**
Bare soil	88.82 %	**100 %**
Meadows	97.18 %	**99.69 %**
Bitumen	89.55 %	**97.37 %**
Gravel	70.36 %	**96.50 %**
Bricks	64.36 %	**89.57 %**
Shadows	98.95 %	93.53 %
Metal sheers	99.57 %	**99.86 %**
Trees	98.65 %	96.24 %
Overall Accuracy	86.43 %	**95.79 %**
Kappa	0.8422	**0.9497**
Time [s]	3.3932	**0.6365**

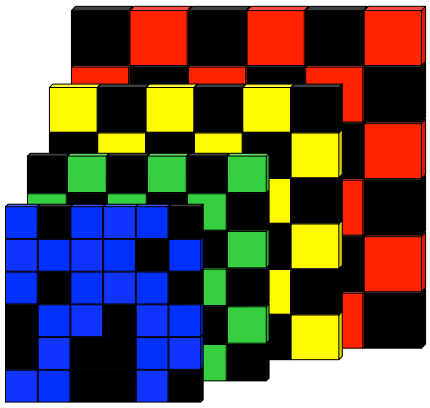
Take away

- Image classification using fused information from RGB superpixels and HSI data.
- The proposed supervised method outperforms the SVM classifier and achieves better classification results.
- In general, a difference of at most 9 % in terms of overall accuracy was observed.
- The best number of superpixels, for the used data set, was 450.



SVM Proposed

Thank you!



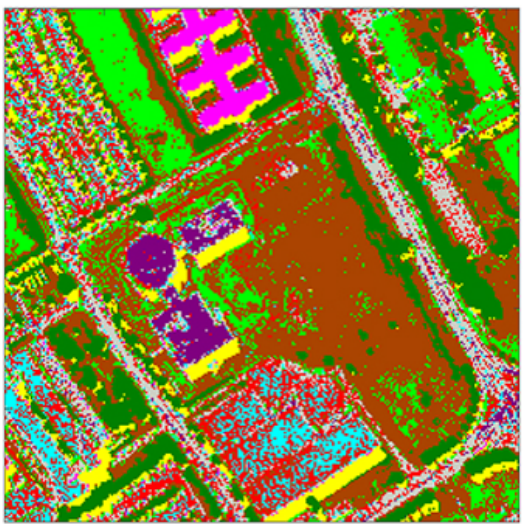
High-**D**imensional **S**ignal
Processing **R**esearch **G**roup
www.hdspgroup.com

OSA®
Imaging and Applied
Optics Congress

Universidad
Industrial de
Santander

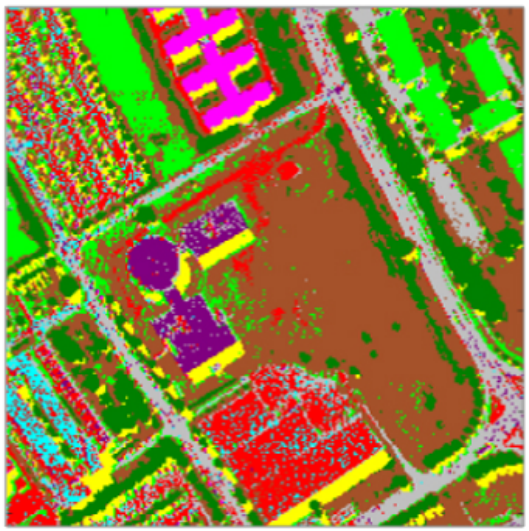
Simulations and Results: HSI with KNN classifier

Hyperspectral image classification without side information with the k-nearest neighbor classifier.



HSI with KNN

OA = 79,72%



HSI with SVM

OA = 86,43%

Simulations and Results: Overall accuracy

- Overall classification accuracy for the proposed method, for HSI with SVM and with the KNN classifier.