Marker-Based Hierarchical Segmentation and Classification Approach for Hyperspectral Data

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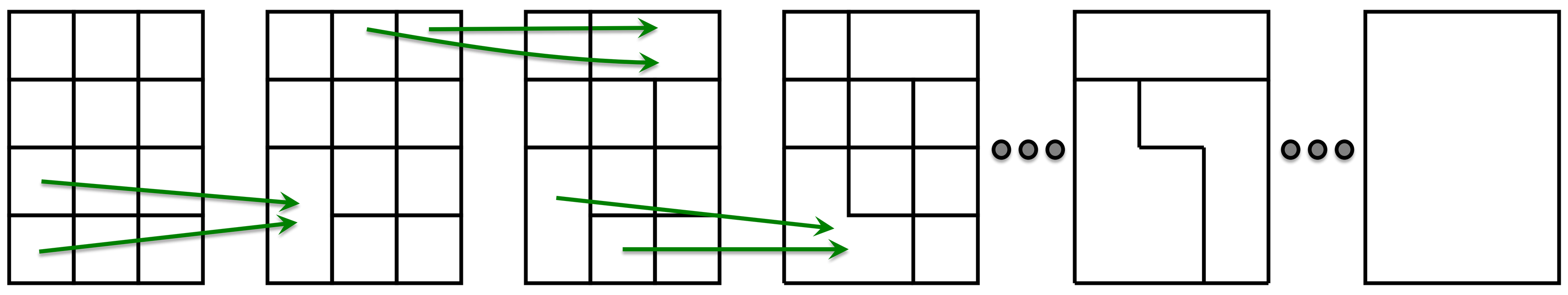
Introduction

- Hyperspectral imaging records a detailed spectrum for each pixel, opening new perspectives in classification.
- Recent studies have shown the advantage of performing a spatial segmentation-based analysis for accurate classification [1, 2].
- Hierarchical Segmentation (HSeg) has shown good performance for spatial analysis of hyperspectral images [3].

HSeg is a combination of hierarchical step-wise optimization and spectral clustering:

1. Each pixel = one region.
2. Find the smallest dissimilarity criterion DC_{min} between adjacent regions.
3. Merge adjacent regions with $DC = DC_{min}$ and non-adjacent regions with $DC \leq S_{wght} DC_{min}$.
4. If not converged, go to step 2.



Where to stop in the hierarchy?

How to automatically select a single hierarchical level?

- We propose and investigate the use of **markers**, or region seeds, for this purpose.
- Markers are automatically selected by analyzing probabilistic classification results.

Hyperspectral data

The Indian Pines image:

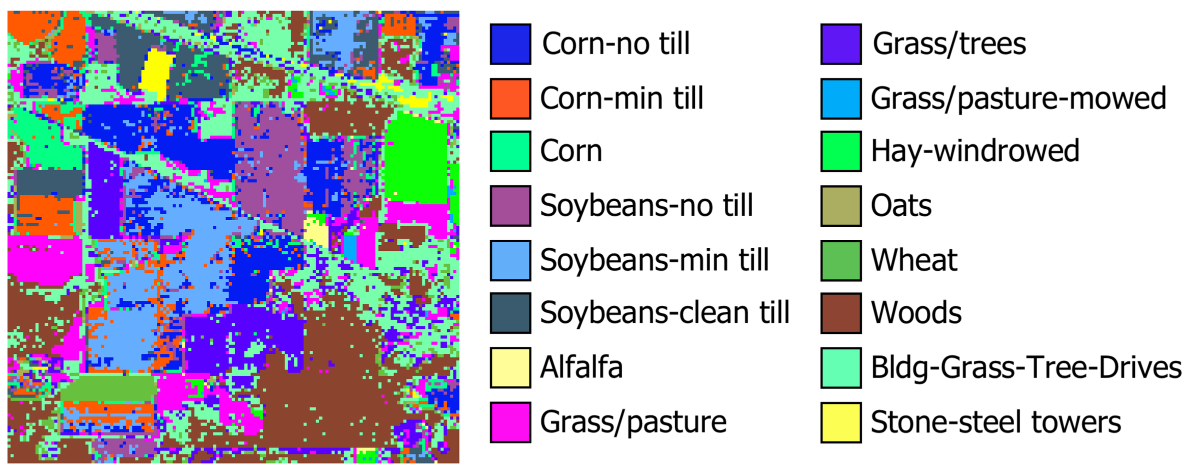
- is recorded by the Airborne Visible/Infrared Imaging Spectrometer over the vegetation area,
- is of 145 by 145 pixels, with a spatial resolution of 20 m/pixel and 200 spectral channels.
- Sixteen classes of interest are considered.

Proposed classification method

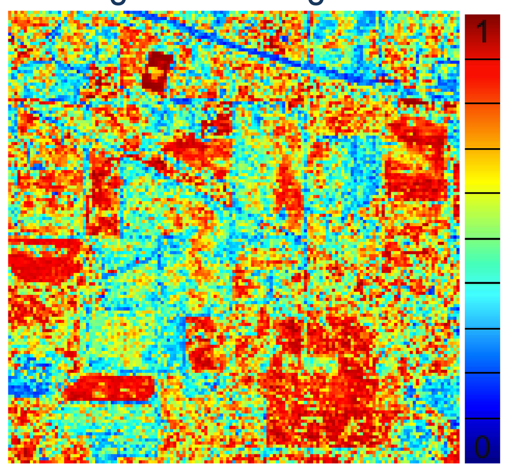
1. Probabilistic pixelwise classification

- Perform a probabilistic Support Vector Machines (SVM) classification [1], in order to obtain:

classification map: each pixel has a unique label



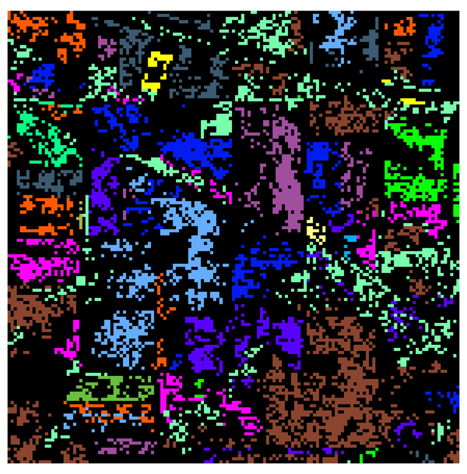
probability map: probability for each pixel to belong to the assigned class



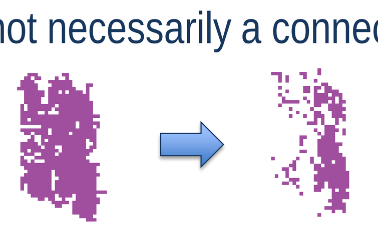
2. Marker selection

Select the **most reliably classified pixels** as **markers** of spatial regions:

- Apply a connected component labeling on the classification map.
- Analyze each connected component:
  a) If it is large (>20 pixels) → use P% (40%) of its pixels with the highest probabilities as a marker.
  b) If it is small → its pixels with probabilities > T% (90%) are used as a marker.

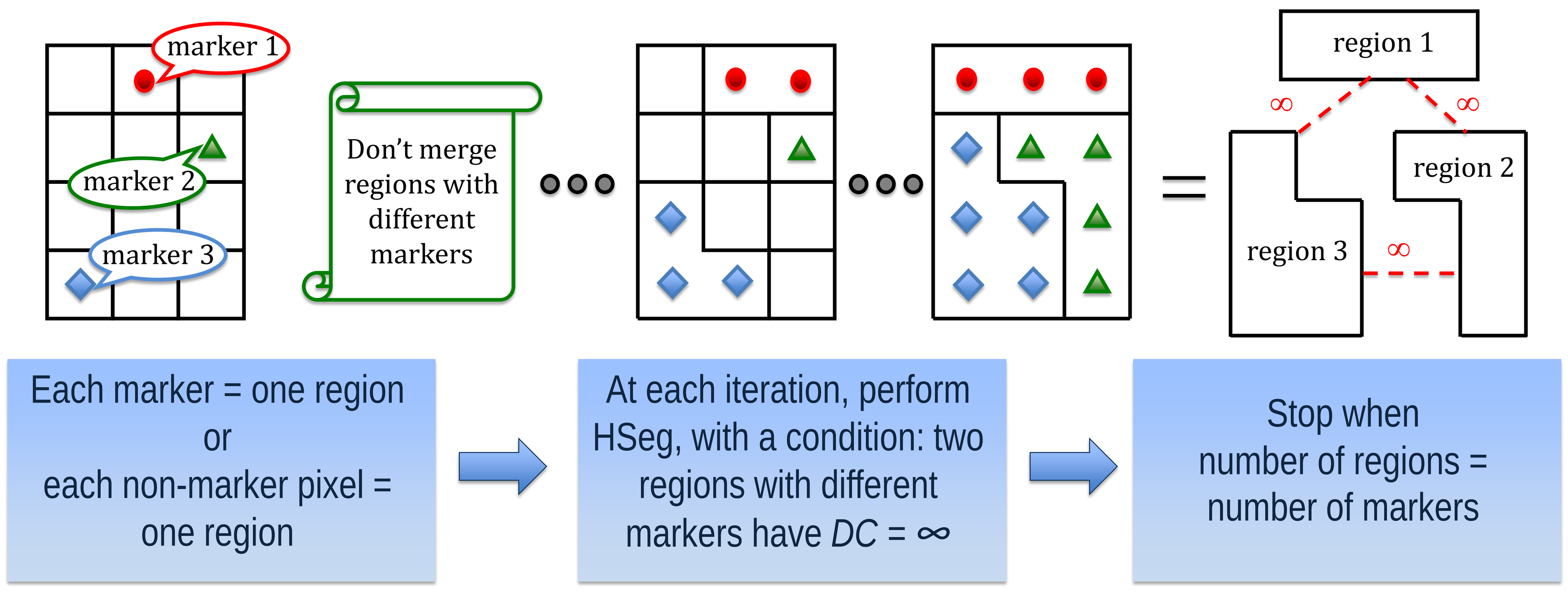


- Each connected component → 1 or 0 marker (2250 regions → 107 markers)
- A marker is not necessarily a connected set of pixels

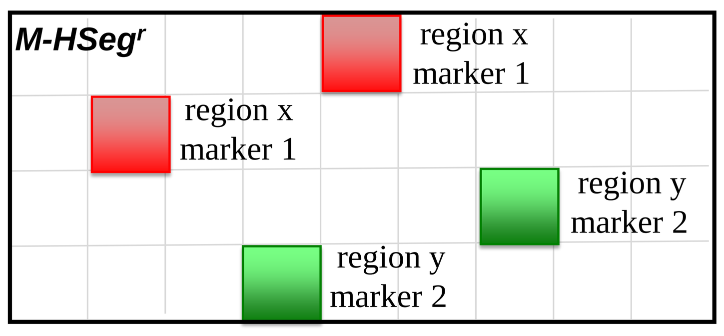


- Each marker has a class label

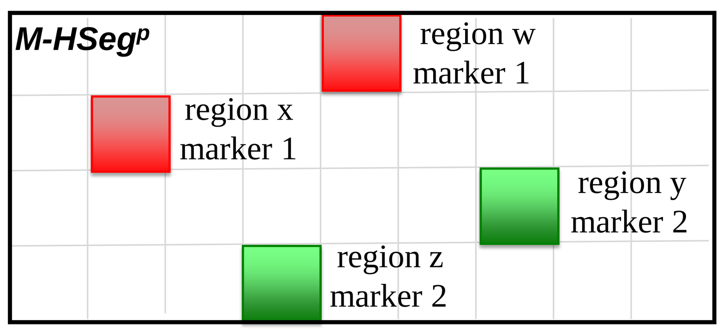
3. Marker-based HSeg



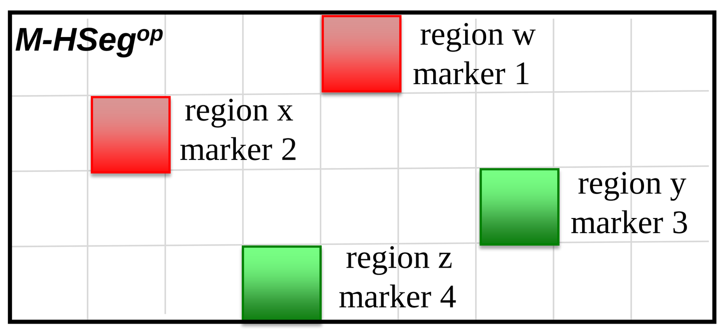
Three implementations of the marker-based HSeg



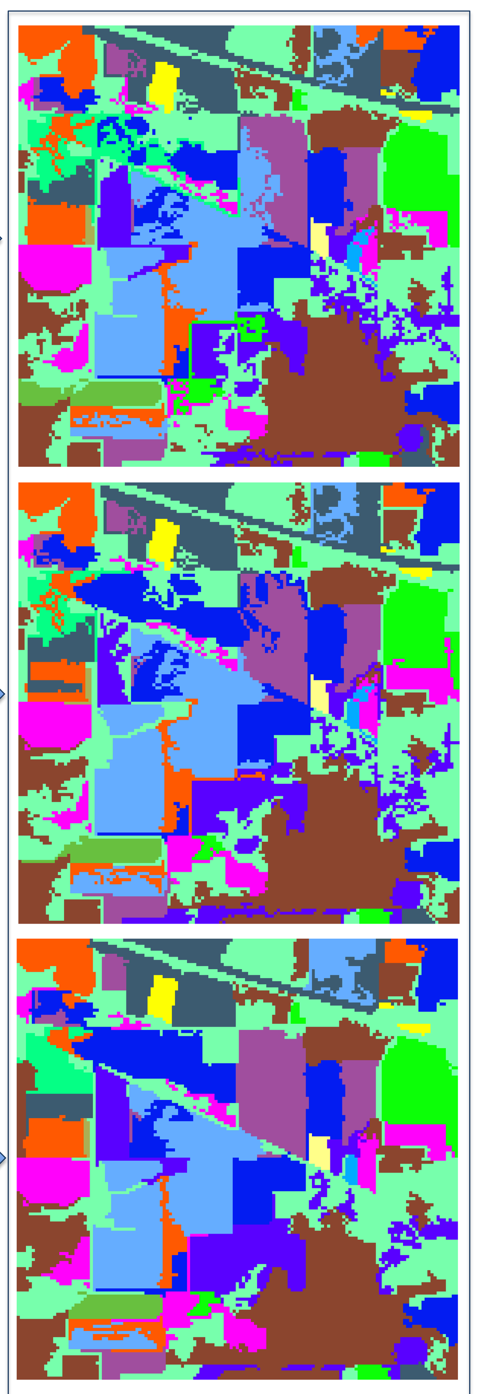
- At initialization, each marker = one region
- Two regions with different markers have $DC = \infty$



- At initialization, each pixel = one region
- Two regions with equal markers have $DC = 0$
- Two regions with different markers have $DC = \infty$



- At initialization, each pixel = one region, each marker pixel obtains a new marker label
- Two regions with different markers have $DC = \infty$
- At the end, regions with the same initial marker are merged



$S_{wght} = 0.0$, $DC = SAM$ between region mean vectors

Classification accuracies in percentage ($DC = SAM$ between region mean vectors)

	M-HSeg^r	M-HSeg^p	M-HSeg^{op}			SVM	SVMMSF [1]
S_{wght}	0.0			0.2	0.5		
Overall Accuracy	77.53	81.59	89.23	88.72	84.74	78.17	**89.65**
Average Accuracy	84.54	87.09	93.44	93.40	90.50	85.97	**93.48**
Kappa coefficient	74.48	79.10	87.72	87.15	82.64	75.33	**88.19**

Conclusions

- A new marker-based HSeg method for spectral-spatial classification of hyperspectral images is proposed.
- The proposed method yields accurate segmentation and classification maps.
- The M-HSeg^{op} implementation significantly outperforms M-HSeg^r and M-HSeg^p implementations in terms of accuracies → A region mean vector may be not an accurate representative of image regions.
- The best results for this image are obtained with $S_{wght} = 0.0$, i.e., when Hseg = Hierarchical Step-Wise Optimization [4].
- In the future, we plan to explore the choice of optimal representative features for segmentation regions.

References

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