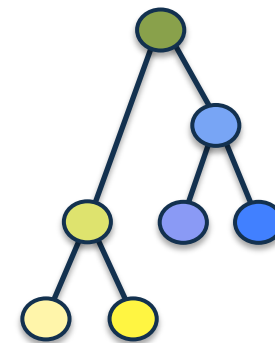




L'Arbre Binaire de Partitions: un outil pour la détection d'objets en imagerie hyperspectral

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Universitat Politecnica de Catalunya**



**Colloque scientifique de la Société Française Télédétection Hyperspectral
Toulouse, 19 Juin 2012**

Outline

- **Introduction**
- BPT construction
- Object detection pruning strategy
- Experimental results
- Conclusions

Processing hyperspectral data

- ❖ Hyperspectral object detection has been mainly developed in the context of pixel-wise spectral classification
- ❖ Objects usually cannot be only characterized by their spectral signature
- ❖ The limitations of pixel-based models motivated the research on developing algorithms performing a region-based analysis

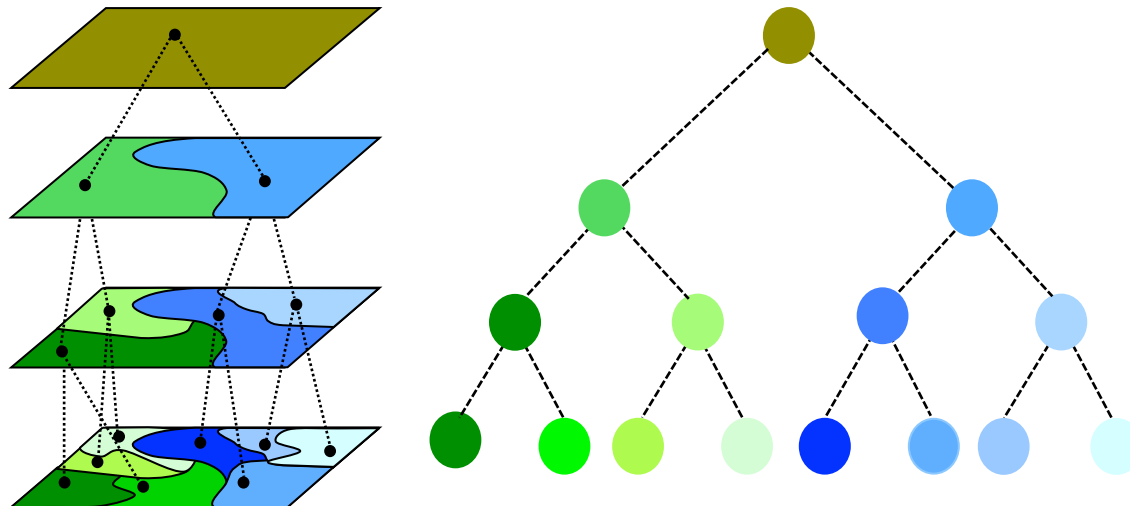


Binary Partition Tree

- ❖ A tree region-based representation is proposed here as a search space for constructing a robust object identification

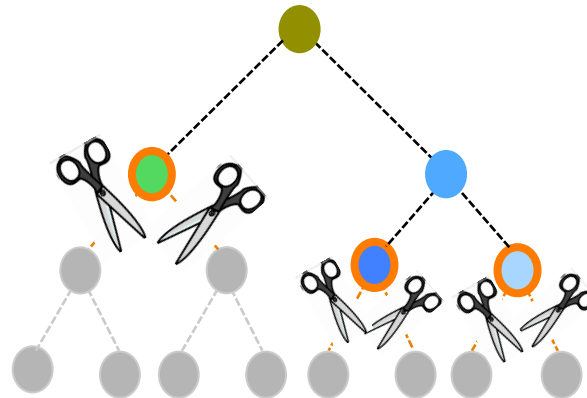
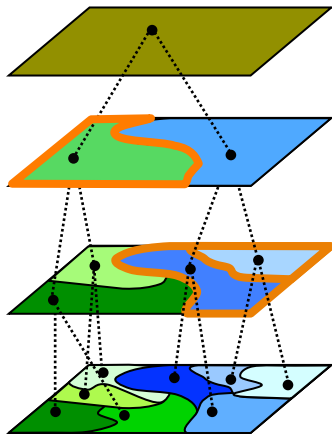
Binary Partition Tree

- ❖ **Binary Partition Trees [Salembier et al. 2000]** are a powerful structured region-based image representation.
- ❖ A BPT contains a set of hierarchical regions stored in a tree structure



Binary Partition Tree

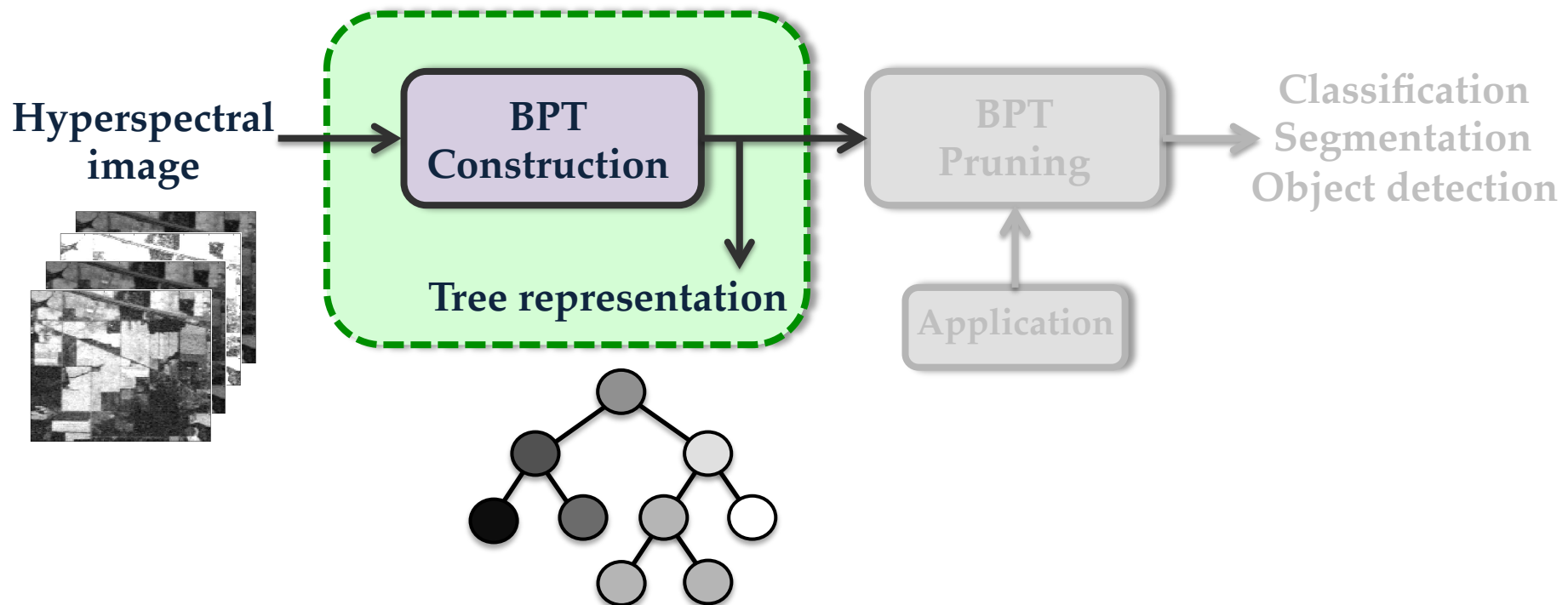
- ❖ **Binary Partition Trees [Salembier et al. 2000]** are a powerful structured region-based image representation.
- ❖ A BPT contains a set of hierarchical regions stored in a tree structure



BPTs enable the extraction of many partitions **at different levels of resolution**

BPT Framework

Construction of a **BPT** from a single hyperspectral image

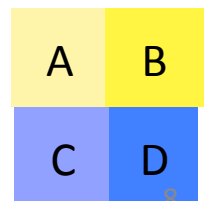
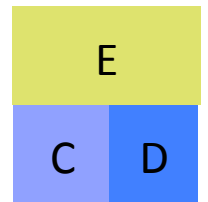
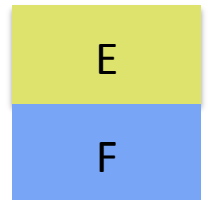
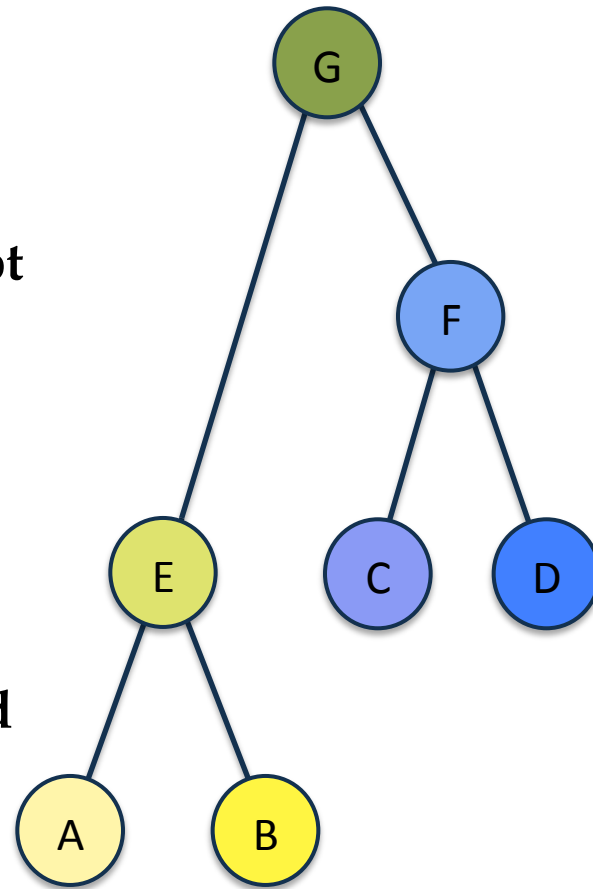


Outline

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- **BPT construction**
- Object detection pruning strategy
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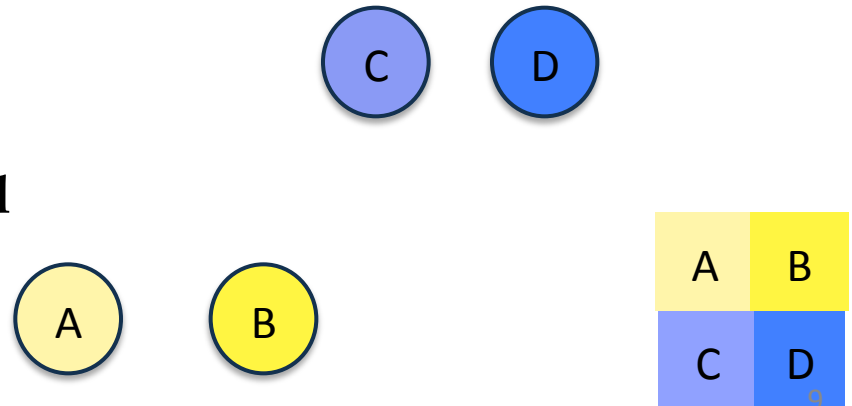
BPT construction

- ❖ The BPT is a hierarchical tree structure representing an image
- ❖ The tree leaves correspond to individual pixels, whereas the root represents the entire image
- ❖ The remaining nodes represent regions formed by the merging of two children
- ❖ The tree construction is performed by an iterative region merging algorithm



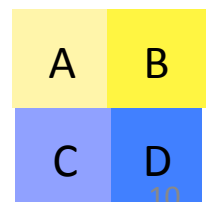
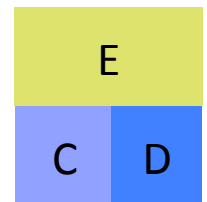
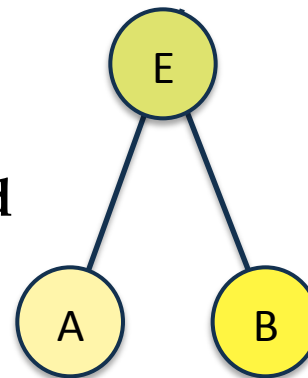
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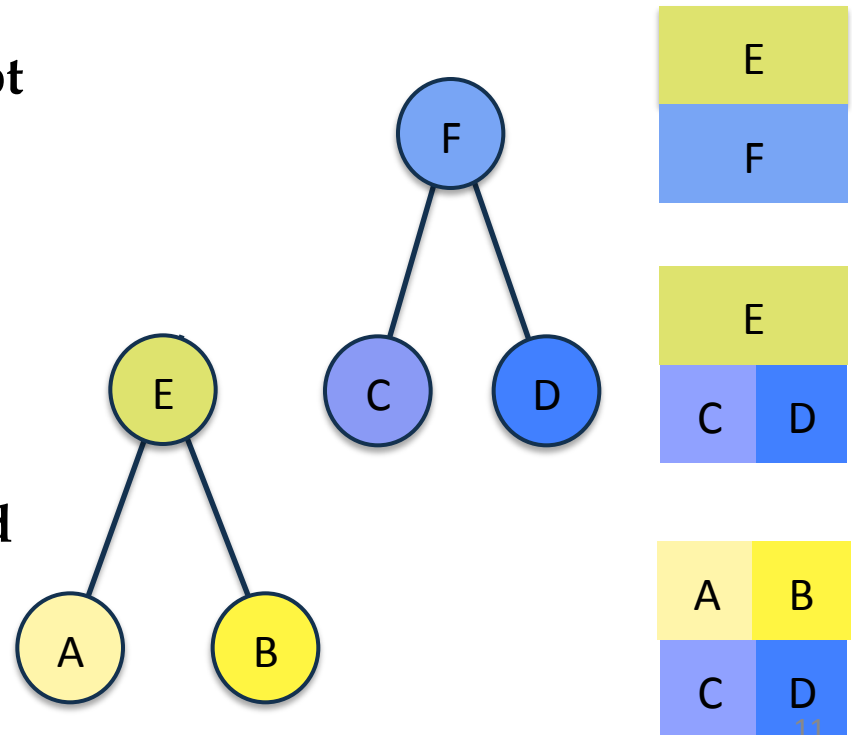
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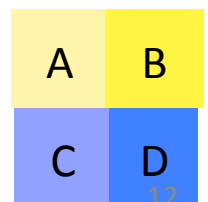
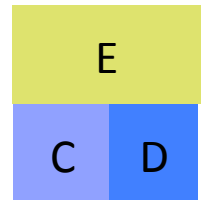
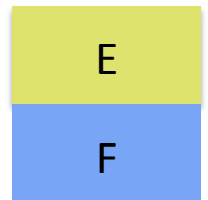
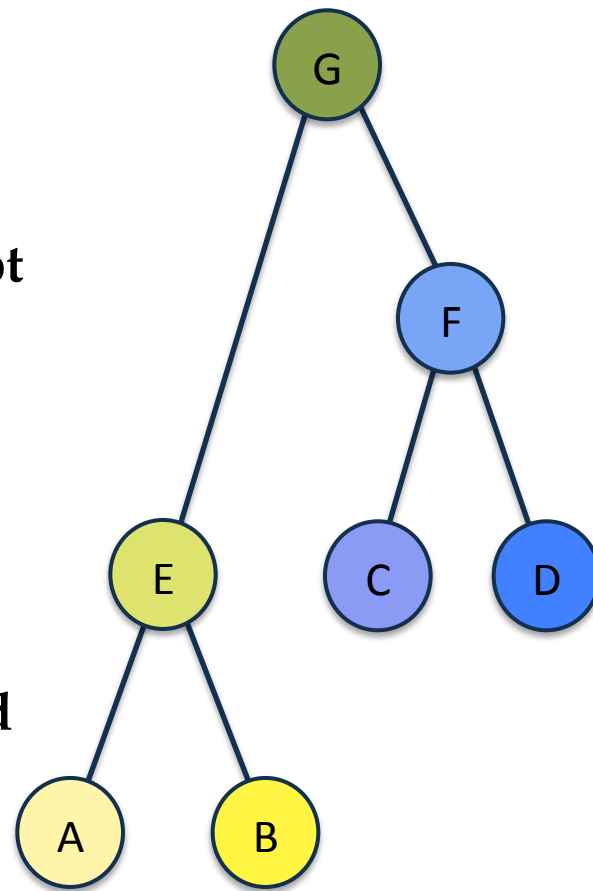
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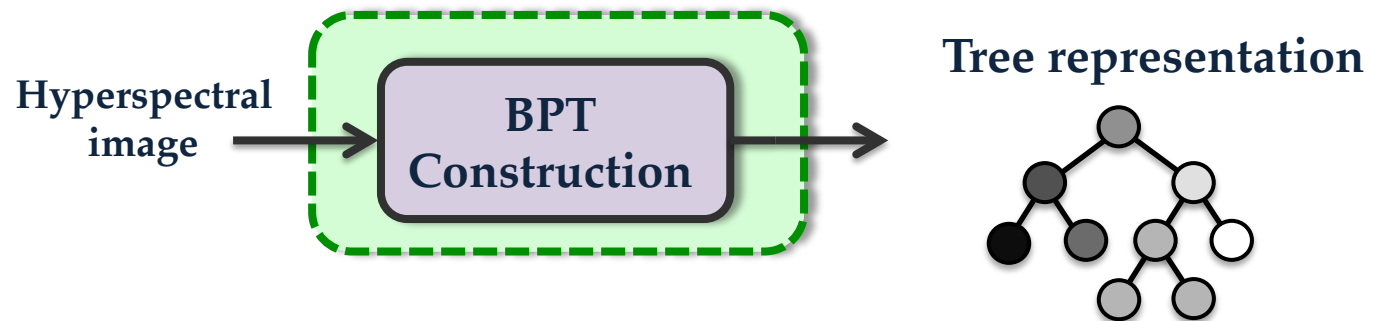
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BPT construction

Construction of a BPT from a single hyperspectral image



Region merging algorithm definition

- ❖ **Region model:**
Mean spectrum of the region
- ❖ **Merging criterion:**

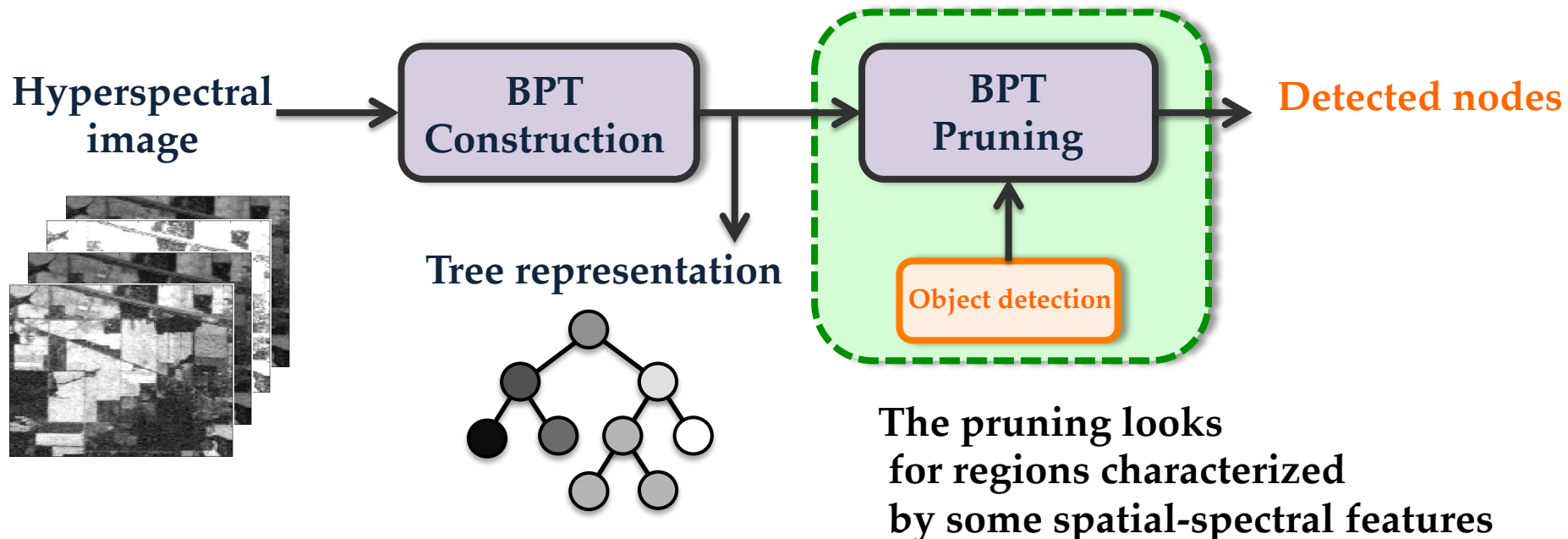
$$O(R_i, R_j) = A_{R_i} \text{SID}(R_i, R_{j \cup i}) \|R_i - R_{i \cup j}\|_2^2 + A_{R_j} \text{SID}(R_j, R_{i \cup j}) \|R_j - R_{i \cup j}\|_2^2$$

Outline

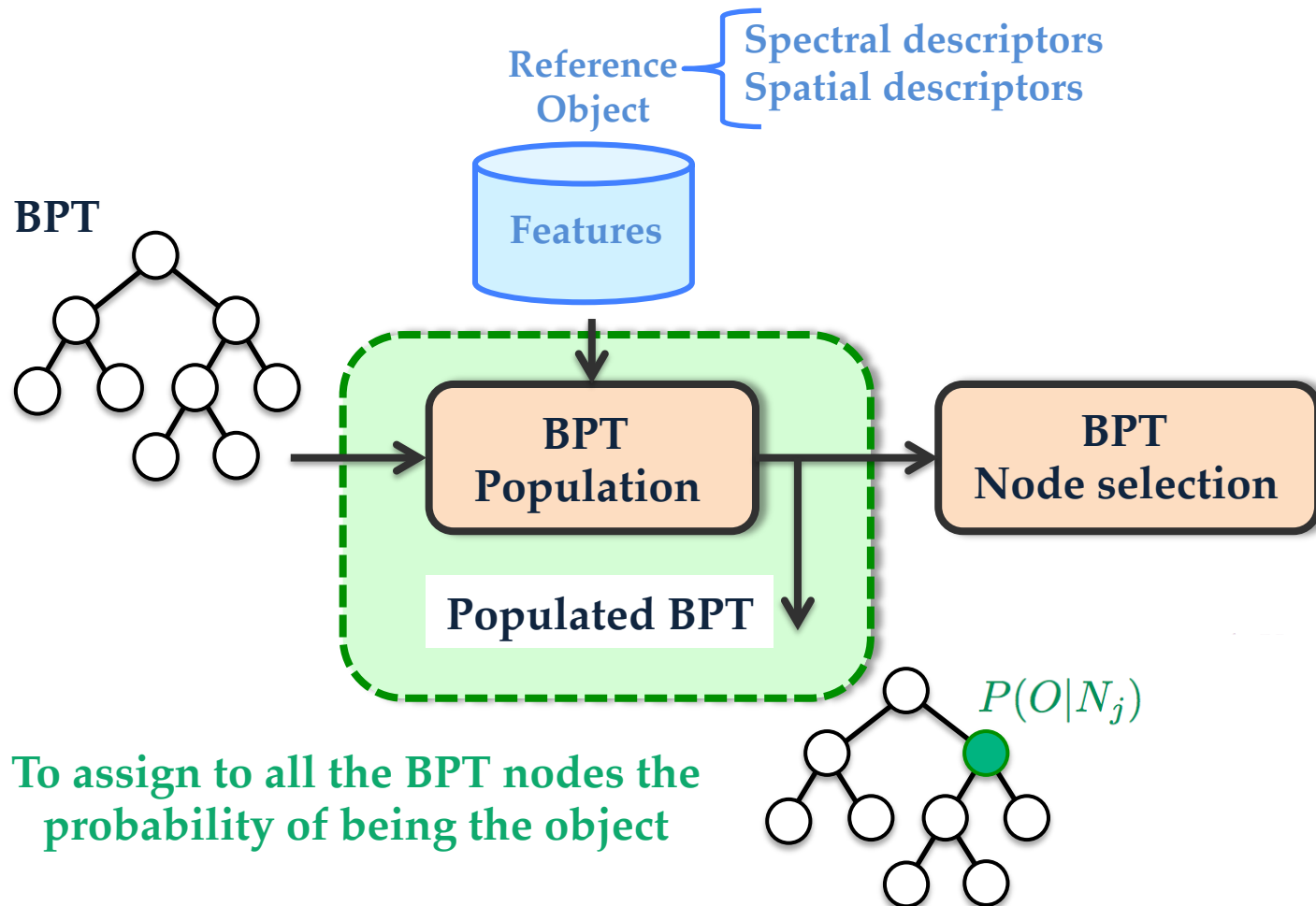
- Introduction
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BPT Framework

Pruning application: **Object detection**

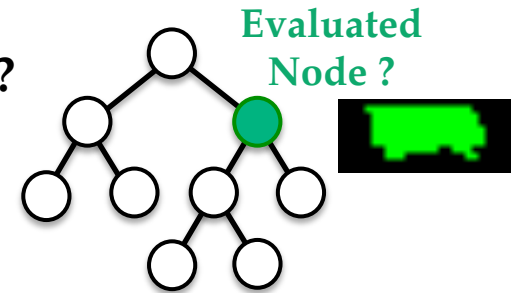


Object detection pruning



Object detection pruning

Does BPT node correspond to the reference object ?



Probability of being the object

$$P(O|N_j) = \left(\prod_{n=1}^K P(F_i|C_r) \right) P(C_r|N_j)$$

Probability of having a coherent region
a set on independent features



Spatial and spectral conditions

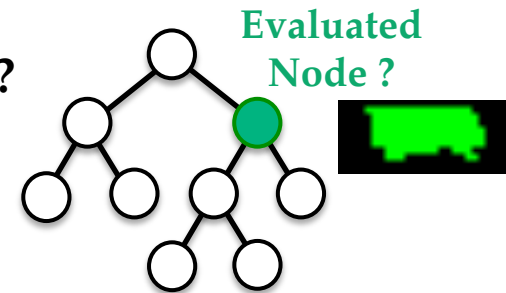
Probability of being
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Best node representing the object

Object detection pruning

Does BPT node correspond to the reference object ?



Probability of being an object

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Probability of being
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Best node representing the object

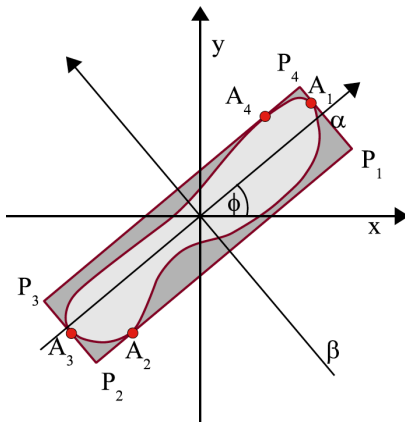
Object detection pruning

Probability of having a coherent region
a set on independent features

$$P(O|N_j) = \left(\prod_{n=1}^K P(F_i|C_r) \right) P(C_r|N_j)$$

Spatial descriptors

Describing information as the area or the shape of the region



- Area of the region
- Occupation on the minimum oriented bounding box
- Elongation of the oriented bounding box
- Minimum bounding box side length
- Compactness
-

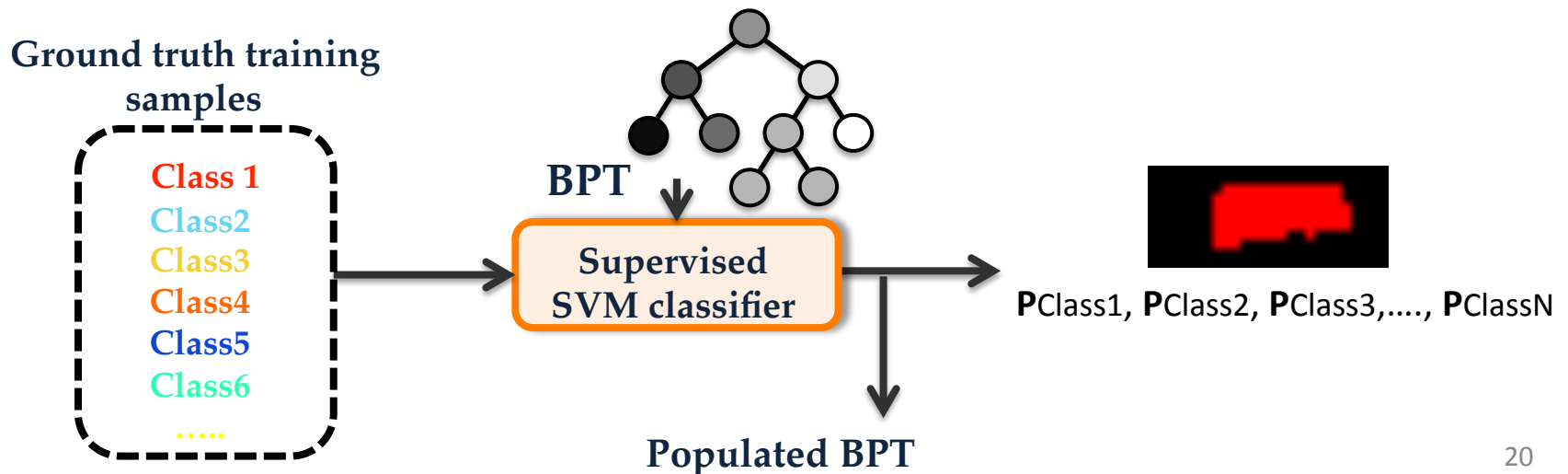
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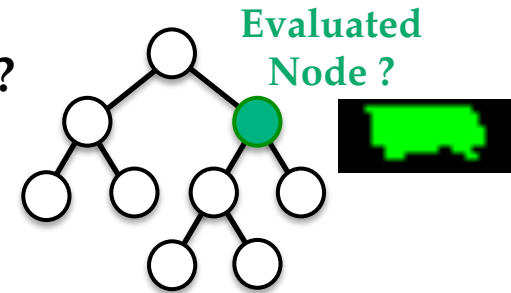
Spectral descriptors

Assigning to each node the probability of belonging to all the possible classes



Object detection pruning

Does BPT node correspond to the reference object ?



Probability of being an object

$$P(O|N_j) = \left(\prod_{n=1}^K P(F_i|C_r) \right) P(C_r|N_j)$$

Probability of having a coherent region
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Spatial and spectral conditions

Probability of being
a coherent region



Best node representing the object

Probability of being a coherent region

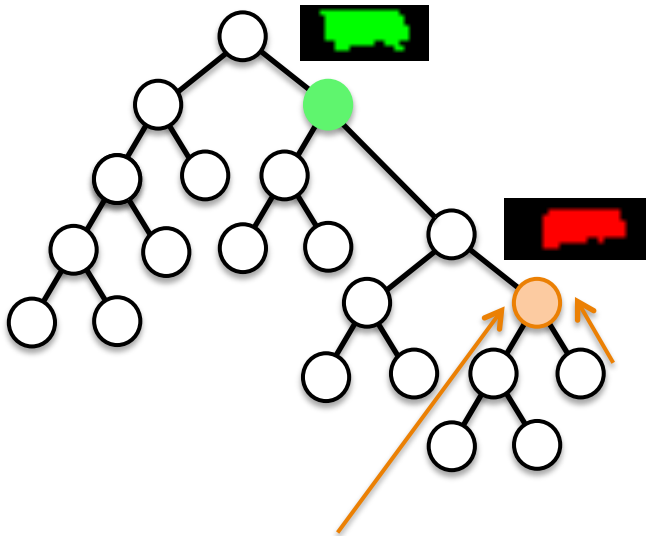
$$P(O|N_j) = \left(\prod_{n=1}^K P(F_i|C_r) \right) P(C_r|N_j)$$

Which is the best level in the branch ??

Object detection pruning

Probability of being a coherent region

$$P(O|N_j) = \left(\prod_{n=1}^K P(F_i|C_r) \right) P(C_r|N_j)$$



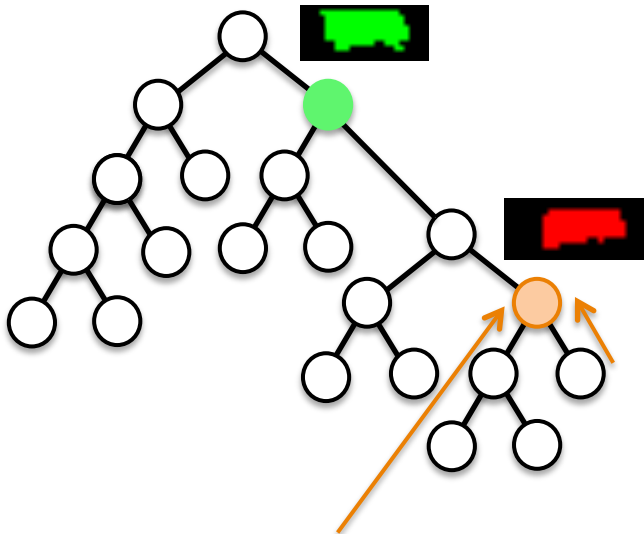
For each node formed at level L : The minimum similarity between two regions merged until L is used as the probability of being a coherent region

A small similarity at level L implies that regions not belonging to the same material has been merged at this level

Object detection pruning

Probability of being a coherent region

$$P(O|N_j) = \left(\prod_{n=1}^K P(F_i|C_r) \right) P(C_r|N_j)$$

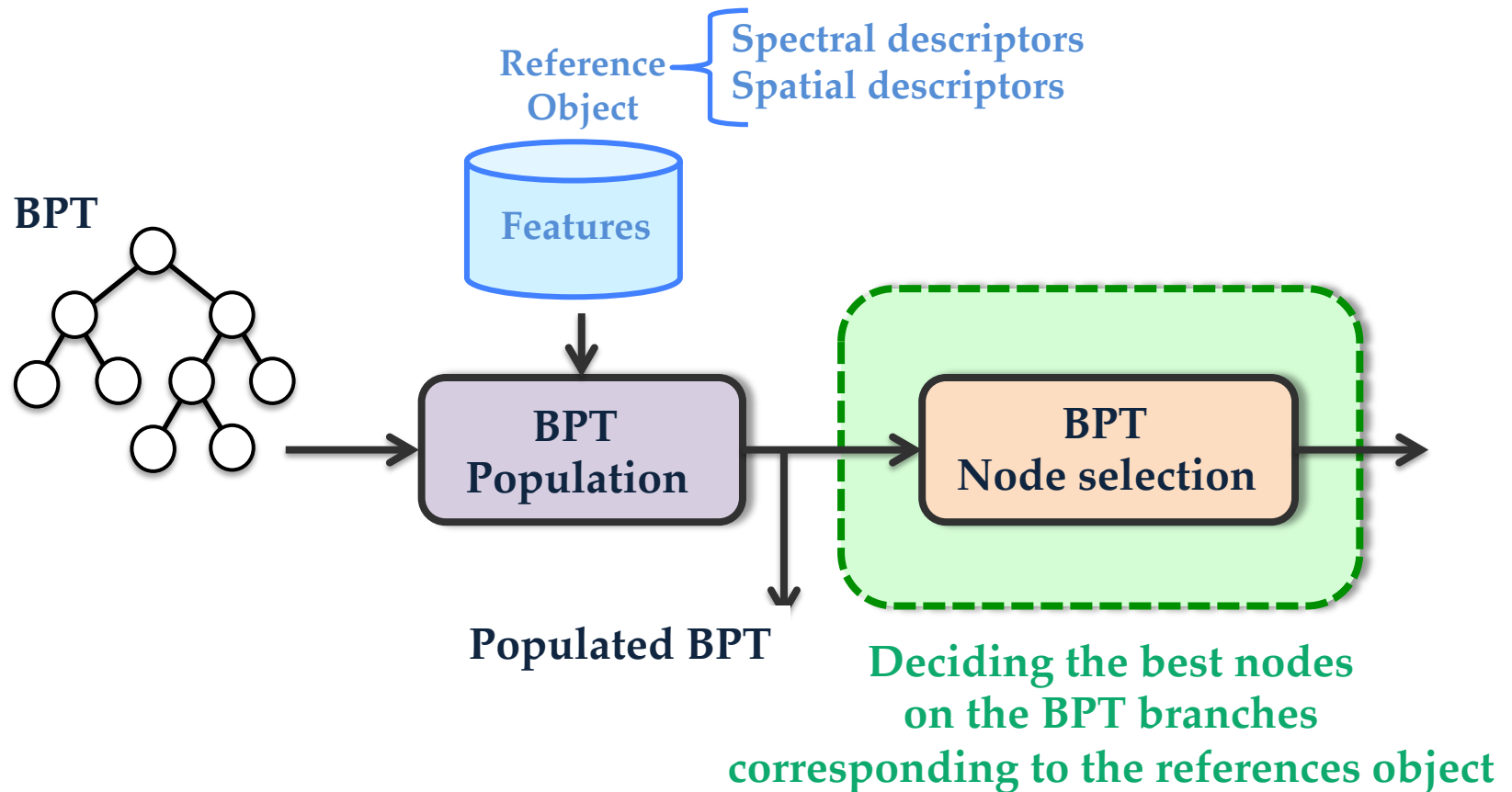


For each node formed at level L: The minimum similarity between two regions merged until L is used as the probability of being a coherent region

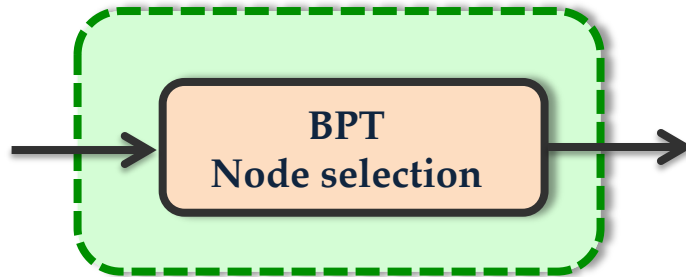
$$P(C_r|N_j \text{ at level } K) = \min_{i=0 \text{ to } K} (BC(\mathcal{P}_{N_{ri}}, \mathcal{P}_{N_{li}}))$$

Being BC the Battacharyya coefficient between the class distributions

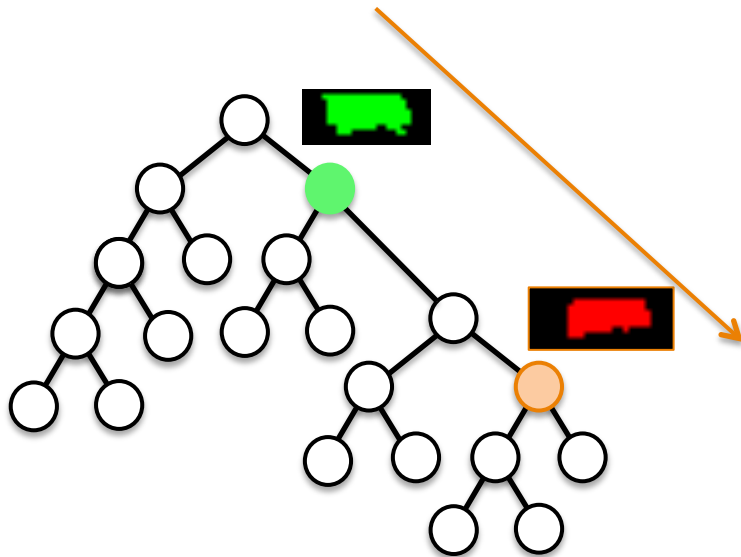
Object detection pruning



Example of object detection



Deciding the best nodes
on the BPT branches
corresponding to the references object



A bottom-up algorithm looking for
the BPT nodes
having the maximum probability of
the branch

$$\max_j P(O|N_j) \text{ where } P(O|N_j) > T_\alpha$$

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Example of object detection



3-band Composition

Urban and Mixed Environment Sample: Reno, NV, USA
356 spectral bands

BPT Construction



250 regions



350 regions



450 regions

Example of object detection

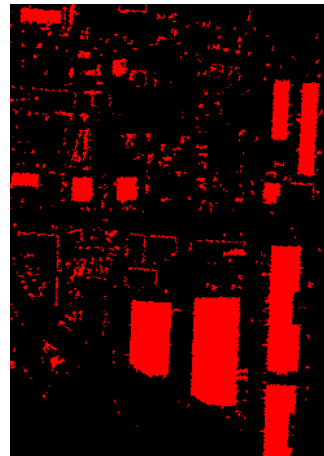
Urban and Mixed Environment Sample: Reno, NV, USA
356 spectral bands

3-band Composition



Building detection

Pixel-wise SVM



BPT approach



Example of object detection

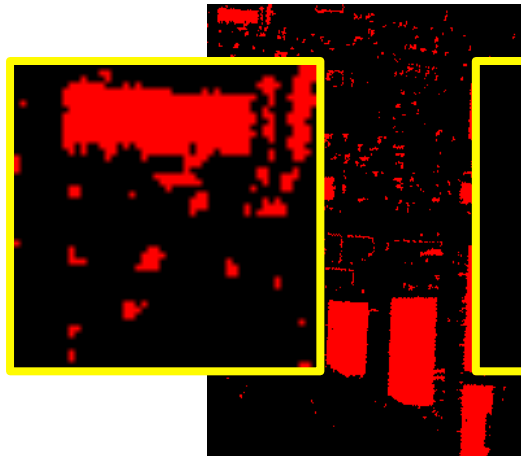
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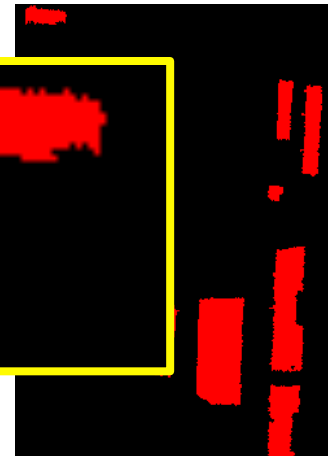


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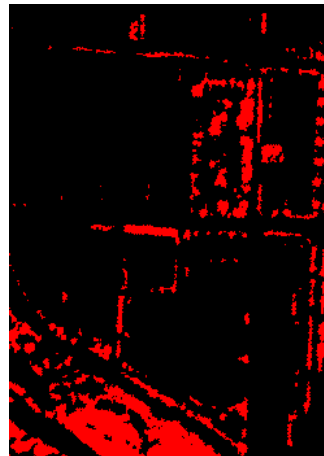
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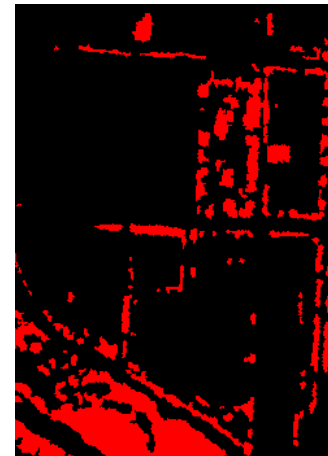


Vegetation Areas

Pixel-wise SVM



BPT approach



Example of object detection

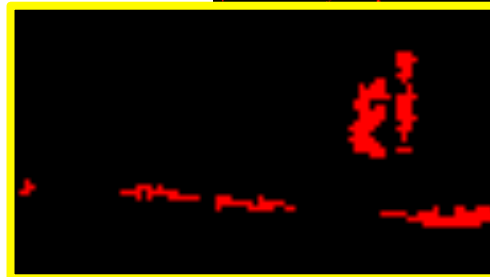
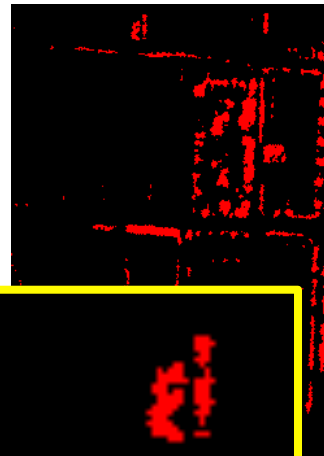
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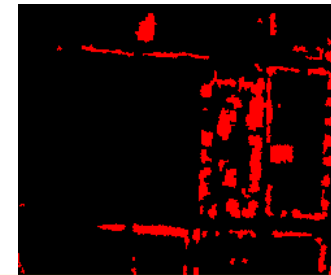


Vegetation Areas

Pixel-wise SVM



BPT approach



Example of object detection



3-band Composition

Urban Hydice Sensor - 210 spectral bands

BPT Construction



250 regions



350 regions



450 regions

Example of object detection

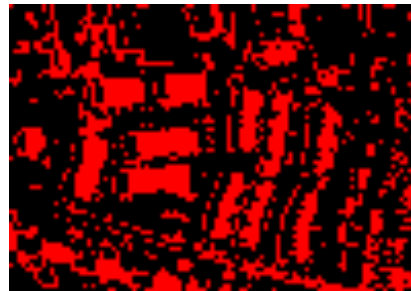


3-band Composition

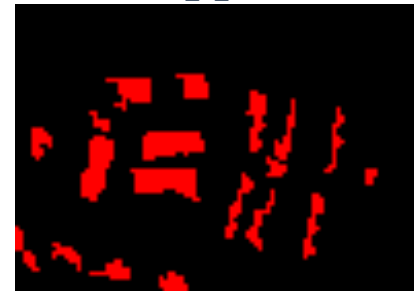
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Building detection

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BPT approach



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Conclusions

- ❖ The **BPT** is proposed as a **search space** for constructing a robust **object identification** scheme.
- ❖ The BPT structure allows us the **analysis of spectral and spatial descriptors** computed on **hypespectral regions**.
- ❖ A **pruning strategy** has been defined in order **to extract** the most likely nodes corresponding to the **references objects**.
- ❖ The **generecity of BPT** representation offers an interesting potential for a **large number of applications**.