BPT Enhancement Based on Syntactic and Semantic Criteria

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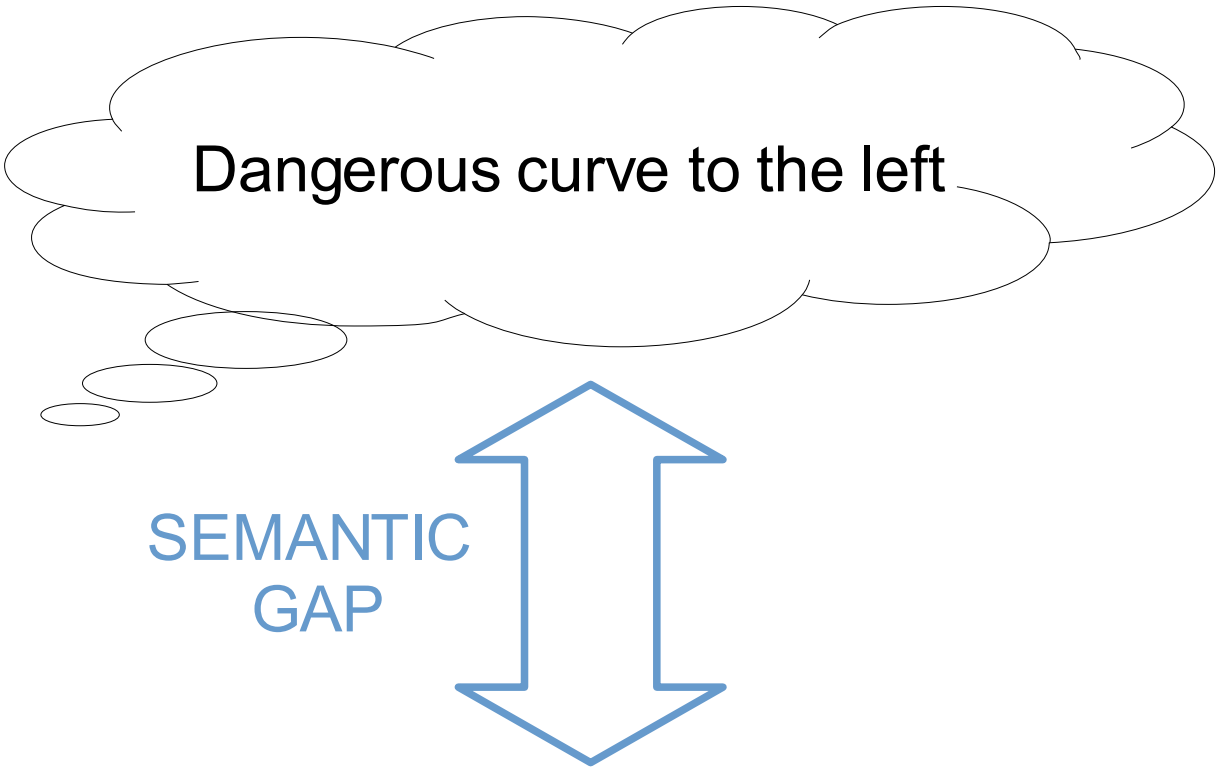
Outline

1. Introduction ←
2. Enhanced BPT Framework
   - Bottom-Up: Syntactic BPT creation
   - Top-down: BPT Semantic analysis
3. Results
   - Application 1: Road-sign detection
   - Application 2: Laptop detection
4. Conclusions

Introduction

- Our goal: A contribution to bridging the semantic gap

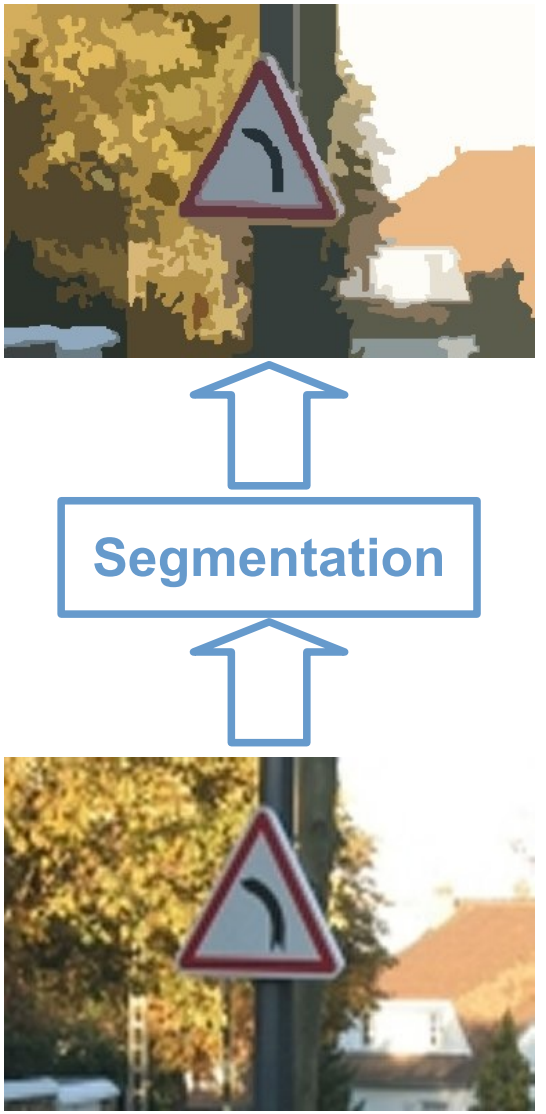


Semantic objects

Perceptual information (visual)

Introduction

- [1] Colour-based segmentation



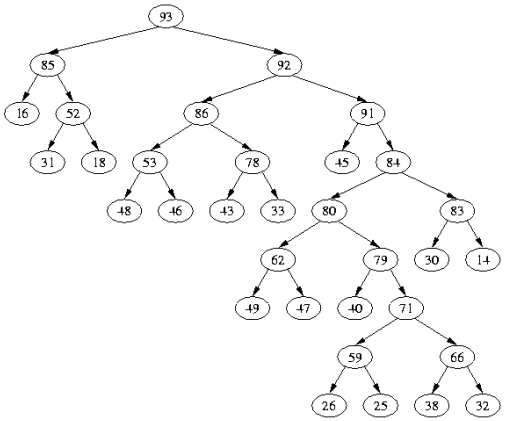
➔ Assumption: Initial partition includes all the contours of represented semantic objects.

[1] P.Salembier and F.Marqués, “Region-based representations of image and video: segmentation tools for multimedia services”, IEEE Trans. Circuits and Systems for Video Technology (1999).

Introduction

- [2] Binary Partition Tree creation
  - Assumption: BPT nodes (or combinations of them) represent all semantic objects

Binary Partition Tree (BPT)



BPT creation

- [3] Syntatic Tree creation
  - Aim: improve the initial segmentation using generic syntactic criteria so that most BPT nodes (or combinations of them) represent all semantic objects

Initial partition

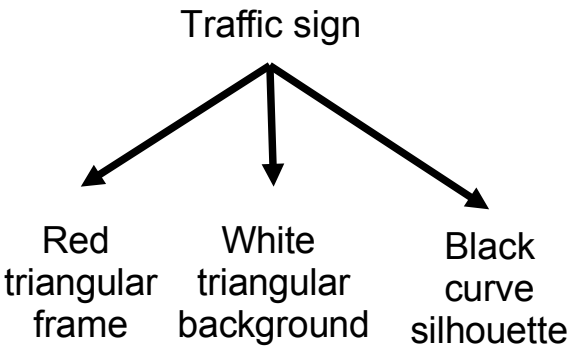
[2] P.Salembier and L.Garrido, "Binary Partition Tree as an efficient representation for image processing, segmentation and information retrieval", IEEE Trans. On Image Processing (2000)

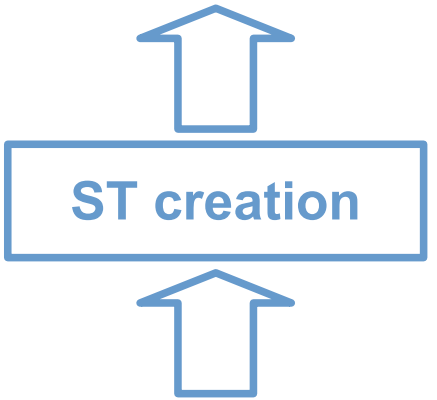
[3] C.Ferran-Bennstrom and J.R.Casas, "Object representation using colour, shape and structure criteria in a binary partition tree," ICIP, Genoa, Italy (2005).

Introduction

- [4] Semantic Tree creation

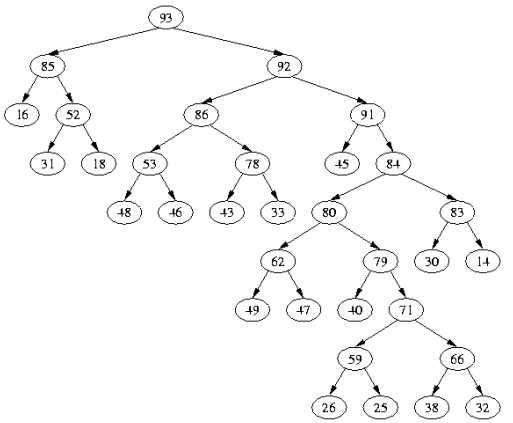
Semantic Tree (ST)





➔ Assumption: Semantic model and classifier effectively deal with visual variability of instances.

Binary Partition Tree (BPT)



[4] X.Giró and F.Marqués, "From Partition Trees to Semantic Trees", MRCS. Istanbul 2006.

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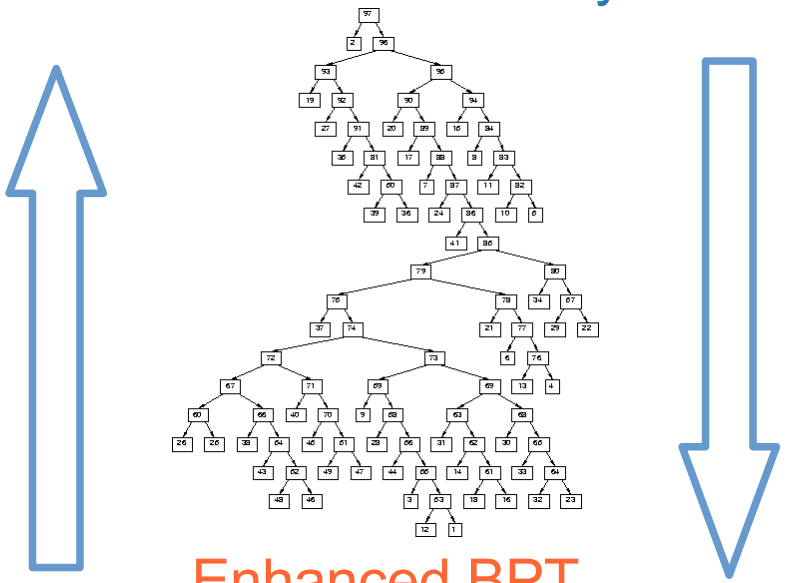
Enhanced BPT

- Two improvements to classic BPT:

TOP-DOWN (TD)
Introduction of BPT Semantic Neighbourhood during BPT analysis.



Enhanced BPT

BOTTOM-UP (BU)
Combination of multiple syntactic features combined with statistical analysis over the whole image for BPT creation.

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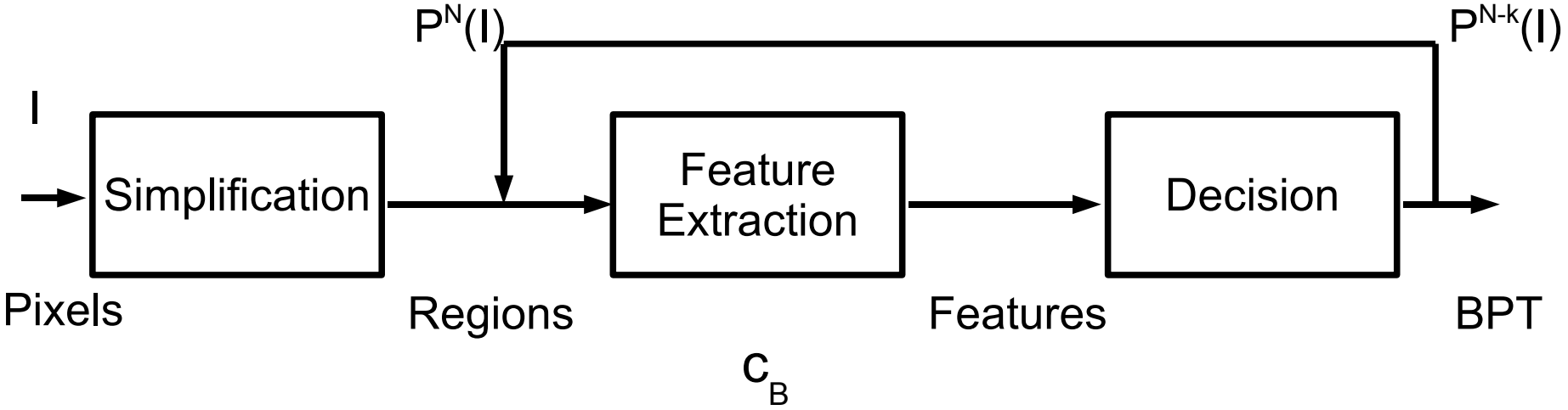
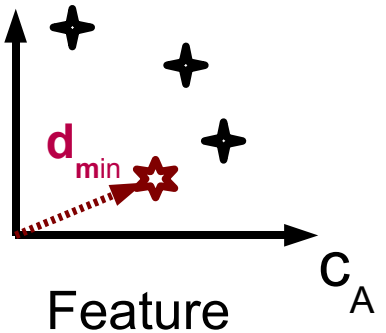
Syntactic BPT creation (BU)

- BPT creation algorithm

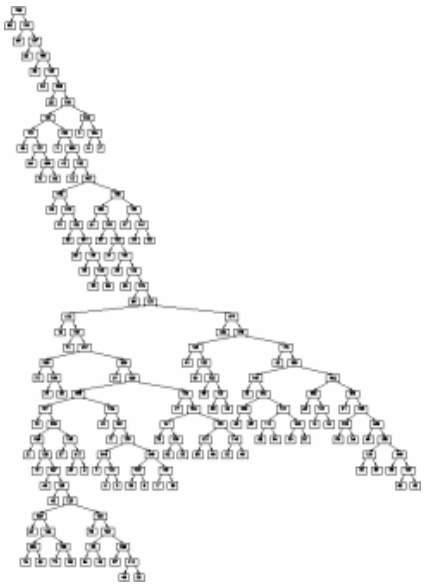


Image

Initial Partition
N Regions



Feature Space



Syntactic BPT creation (BU)

- Classic BPT creation criteria is based on low level features (colour, texture, motion).
- Enrich with mid-level syntactic features based on Gestalt psychology and perceptual grouping approaches.
- BPT creation using the Syntactic Segmentation Framework

Syntactic features:

- Simple and complex homogeneity criteria
- Dissimilarity measures

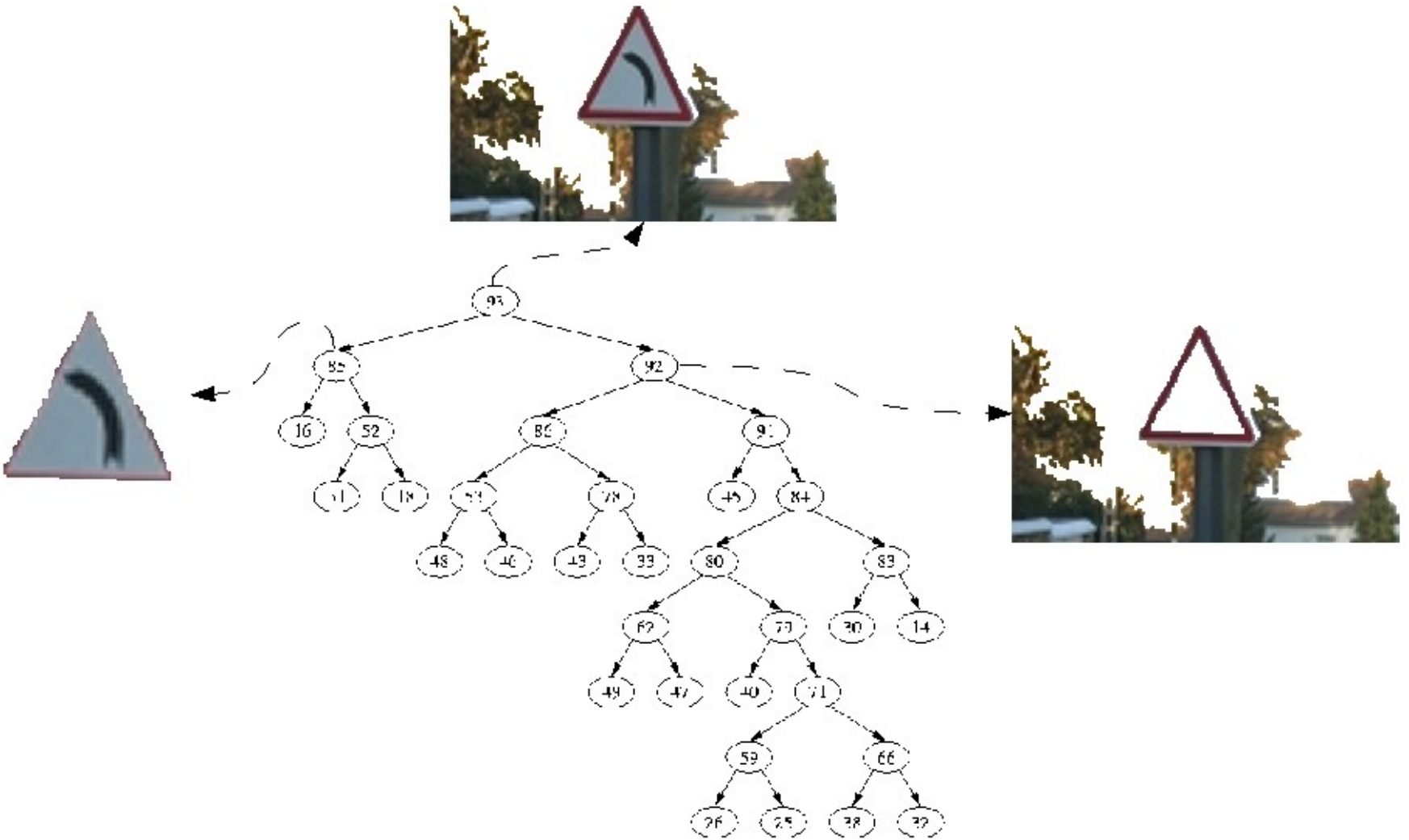
Statistical analysis of dissimilarity measures

- Estimation criterion distribution
- Assumption: uniform distribution of dissimilarity measures are associated with less significant criteria.
- Combination of the criteria using entropy-based dissimilarity

d=f(Entropy,Dissimilarity)

Syntactic BPT creation (BU)

Example: Color-based BPT



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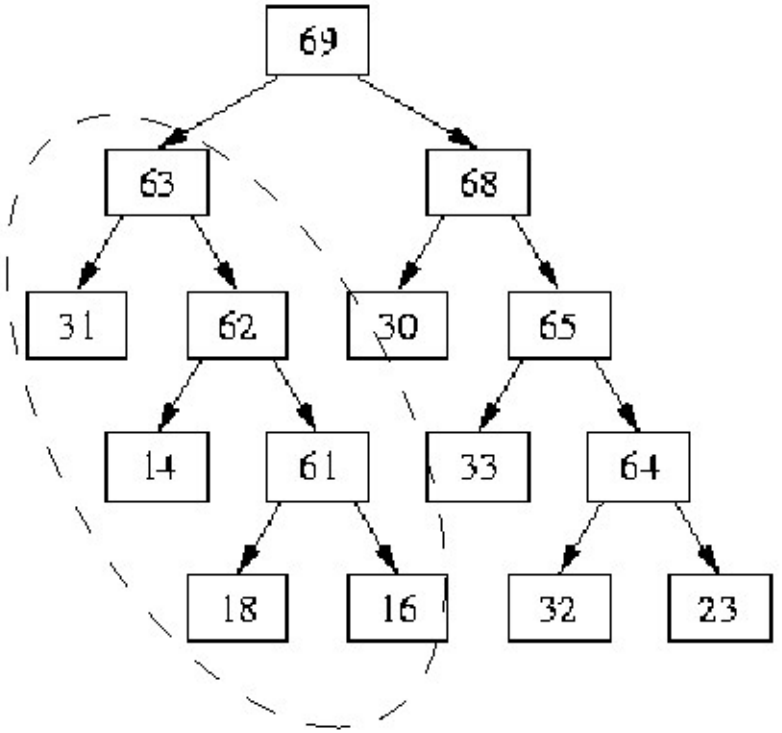
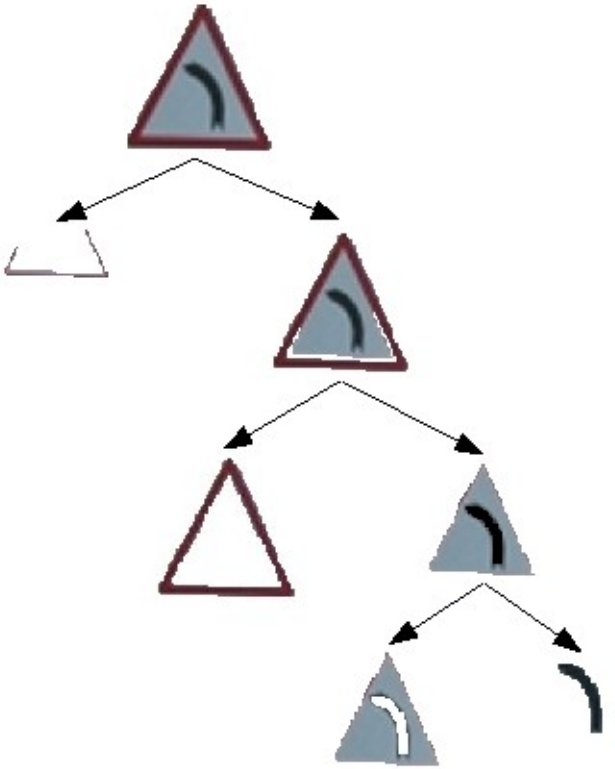
Syntactic BPT creation (BU)

Example: Syntactic-enhanced BPT



(a)



(b)

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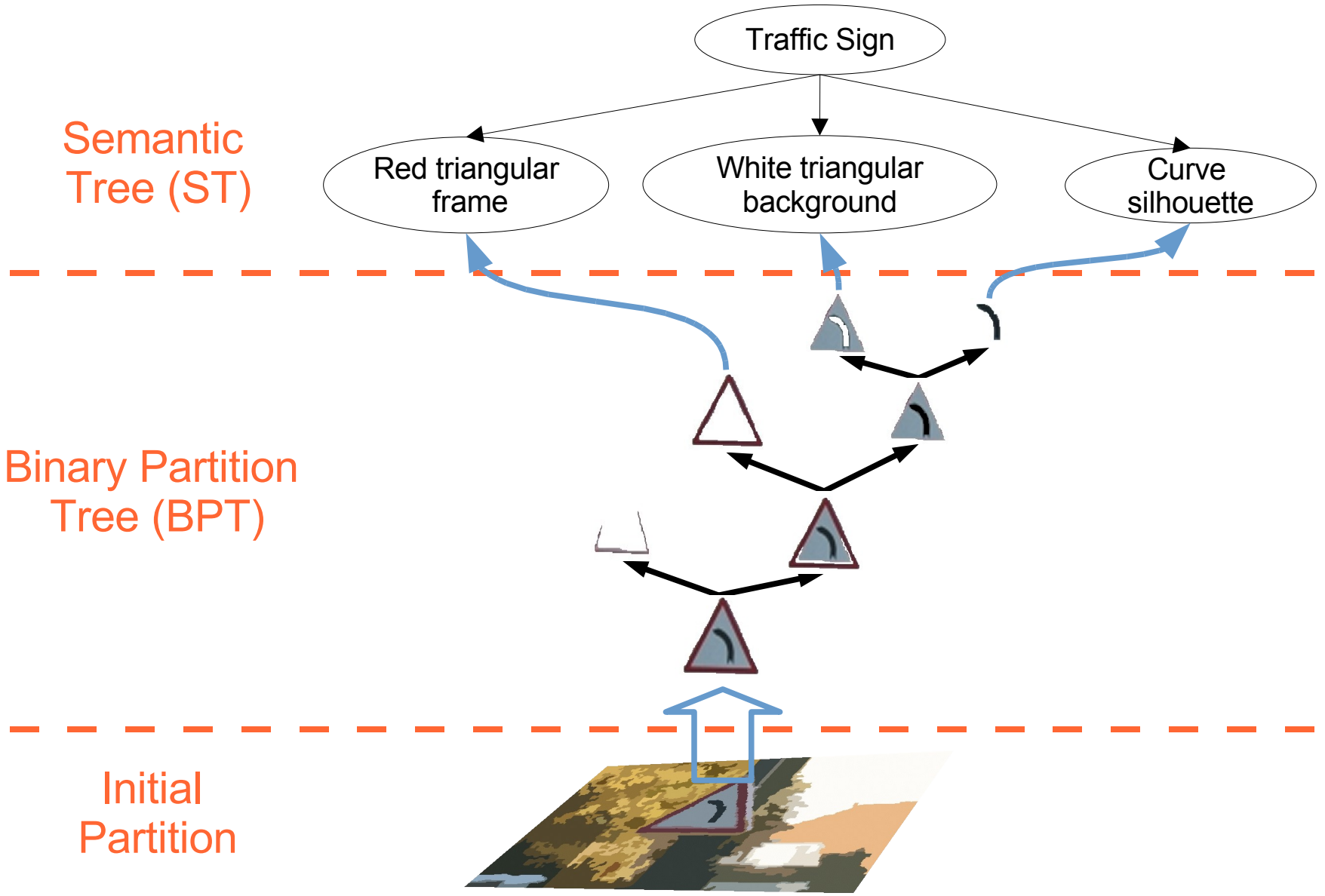
BPT semantic analysis (TD)

- Goal: Analyse BPT and build a Semantic Tree on it.



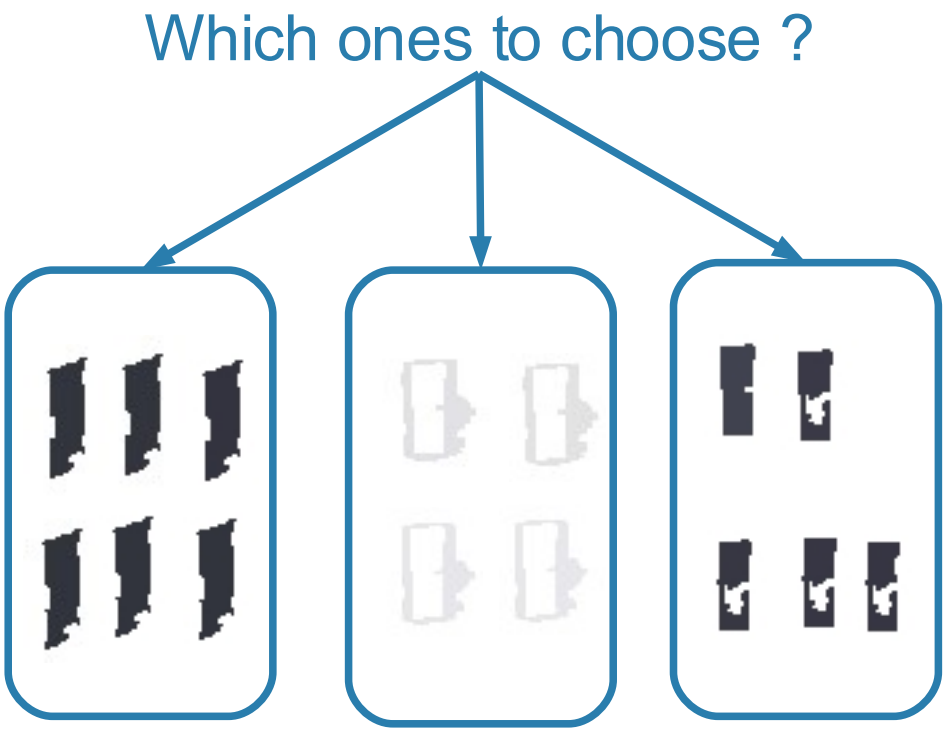
BPT semantic analysis (TD)

- Neighbour BPT nodes may have similar perceptual features
- Problem: Multiple detections of a single instance.

Example: BPT nodes representing laptop screen and keyboard

Image

Initial partition

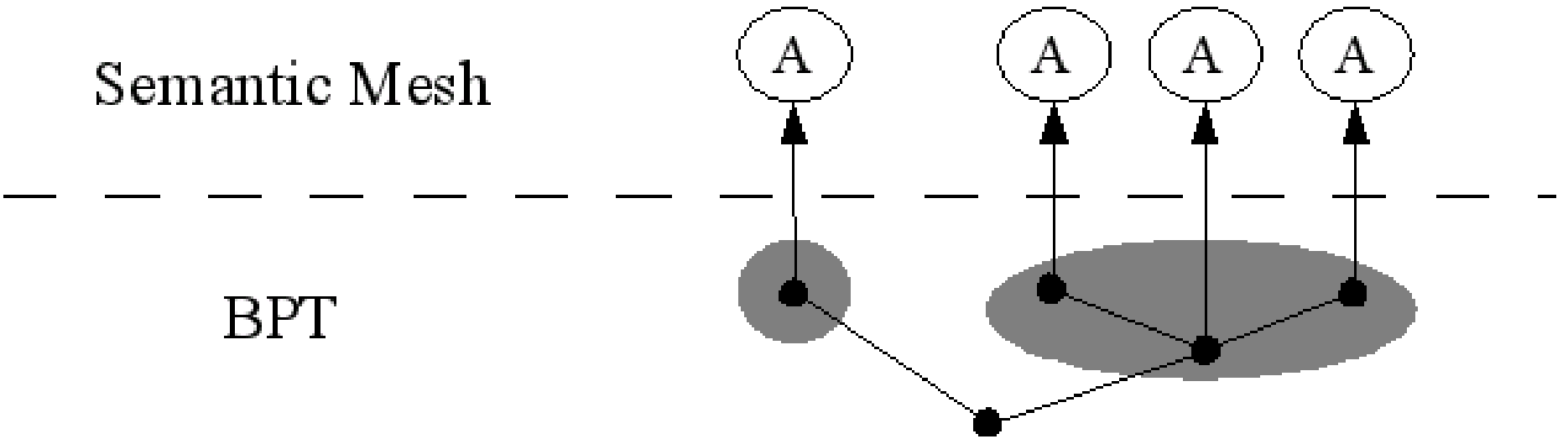


BPT nodes

BPT semantic analysis (TD)

- New definition:
  - BPT Semantic Neighbourhood: subset of connected BPT nodes that represent instances of the same semantic object.

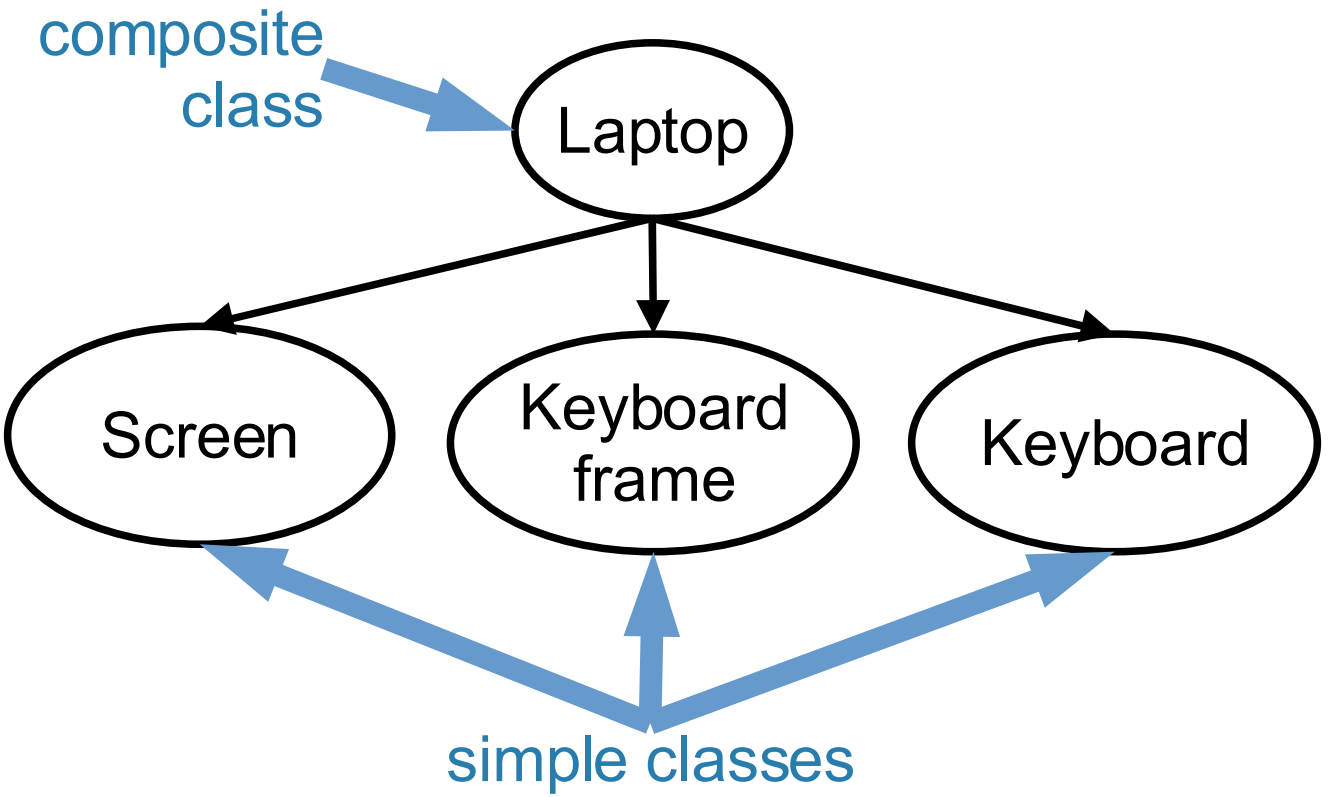
Example: Two BPT Semantic Neighbourhoods of class "A"



BPT semantic analysis (TD)

- ST nodes represent object instances.
- Two types of class:
  - simple: represented by a single BPT node
  - composite: represented by two or more BPT nodes (eg. DG)

Example: ST of "Laptop"



BPT semantic analysis (TD)

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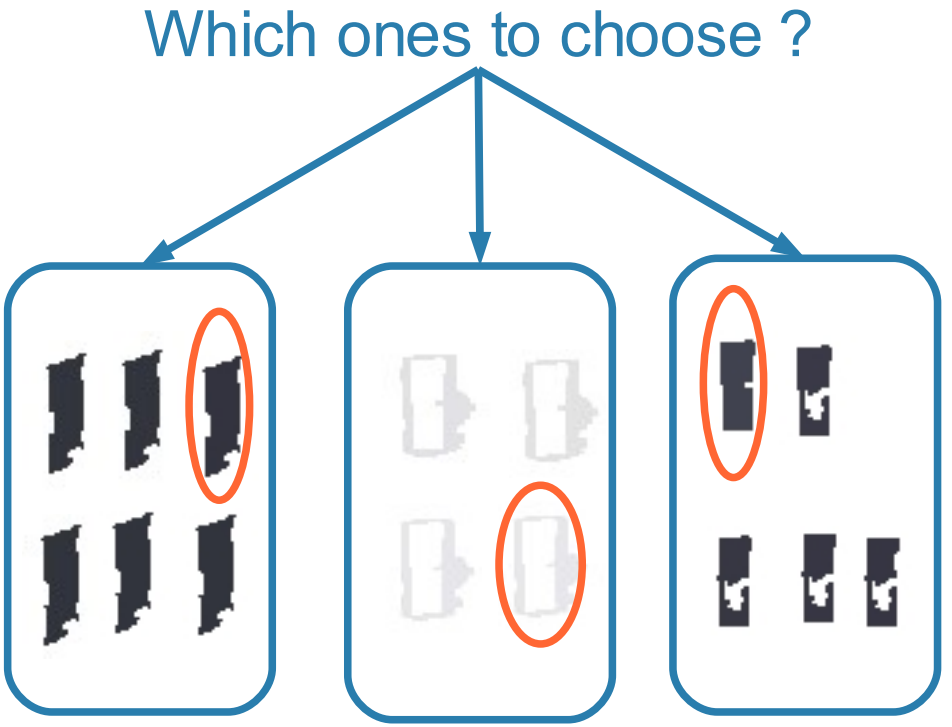


Simple class ➔

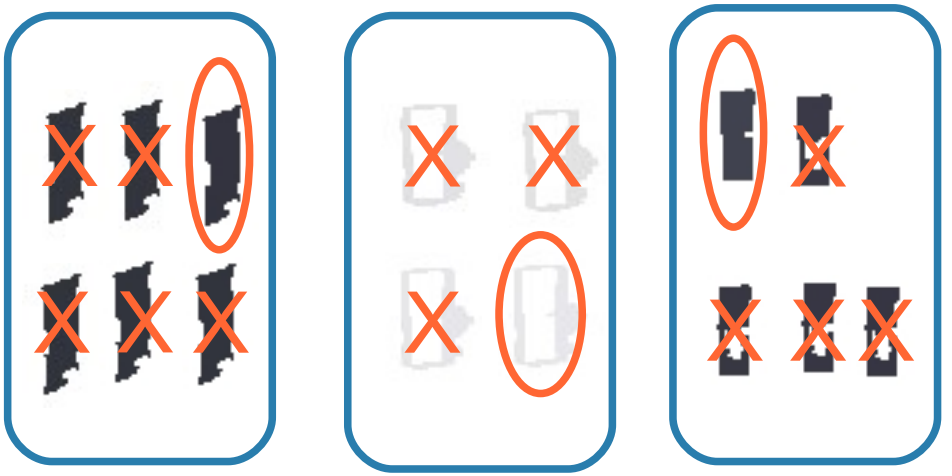
"Best match" to perceptual model

Composite class ➔

"Best match" to structural model
(context-based decision)

BPT semantic analysis (TD)

- Keep “best match” and discard the rest of detected instances.



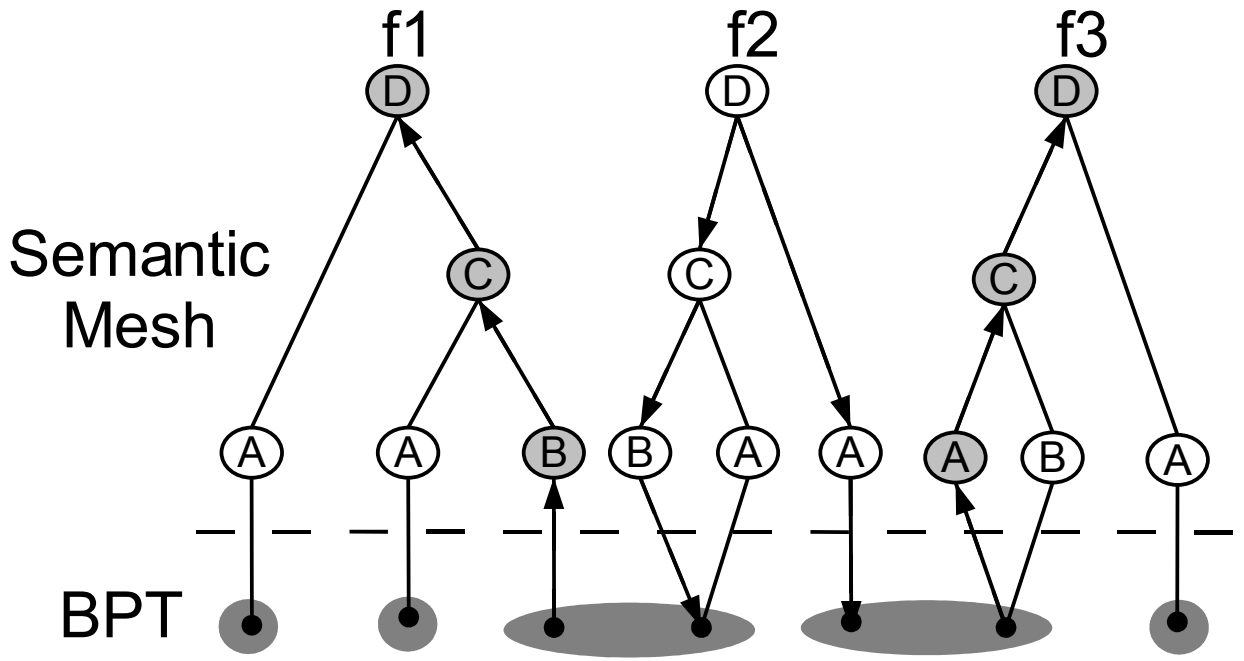
➔ Assumption: A BPT Semantic Neighbourhood only represents one instance of the associated semantic object.

BPT semantic analysis (TD)

- What does “best match” mean ?

  Simple class [5] ➔ Most similar visual descriptors

  Composite class [3] ➔ 1) Higher Semantic Tree (ST)
  2) If same height, highest confidence



[5] V.Vilaplana et al, “Region-based extraction and analysis of visual objects information”, CBMI. Riga 2005.
[3] X.Giró and F.Marqués, “From Partition Trees to Semantic Trees”, MRCS. Istanbul 2006.

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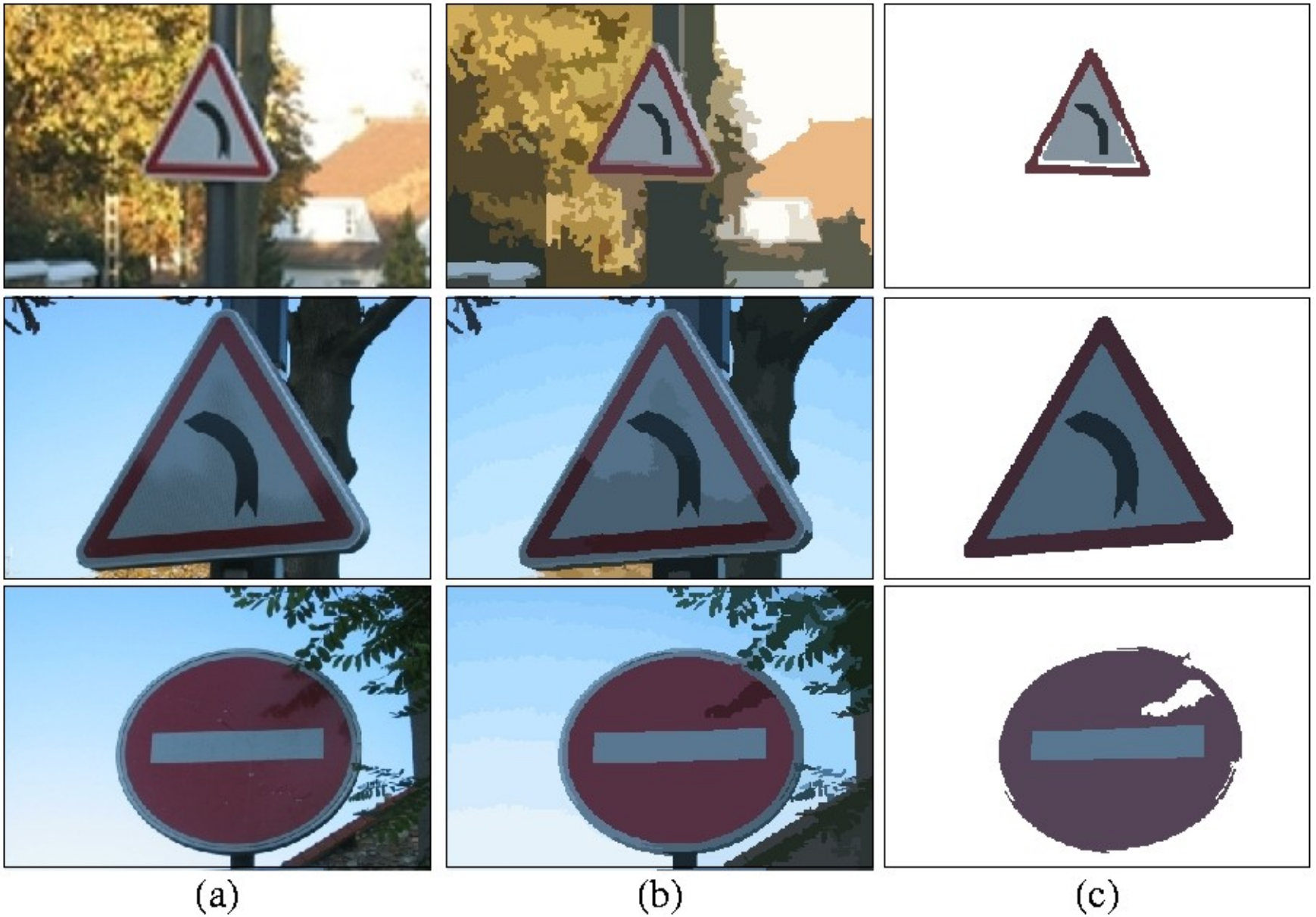
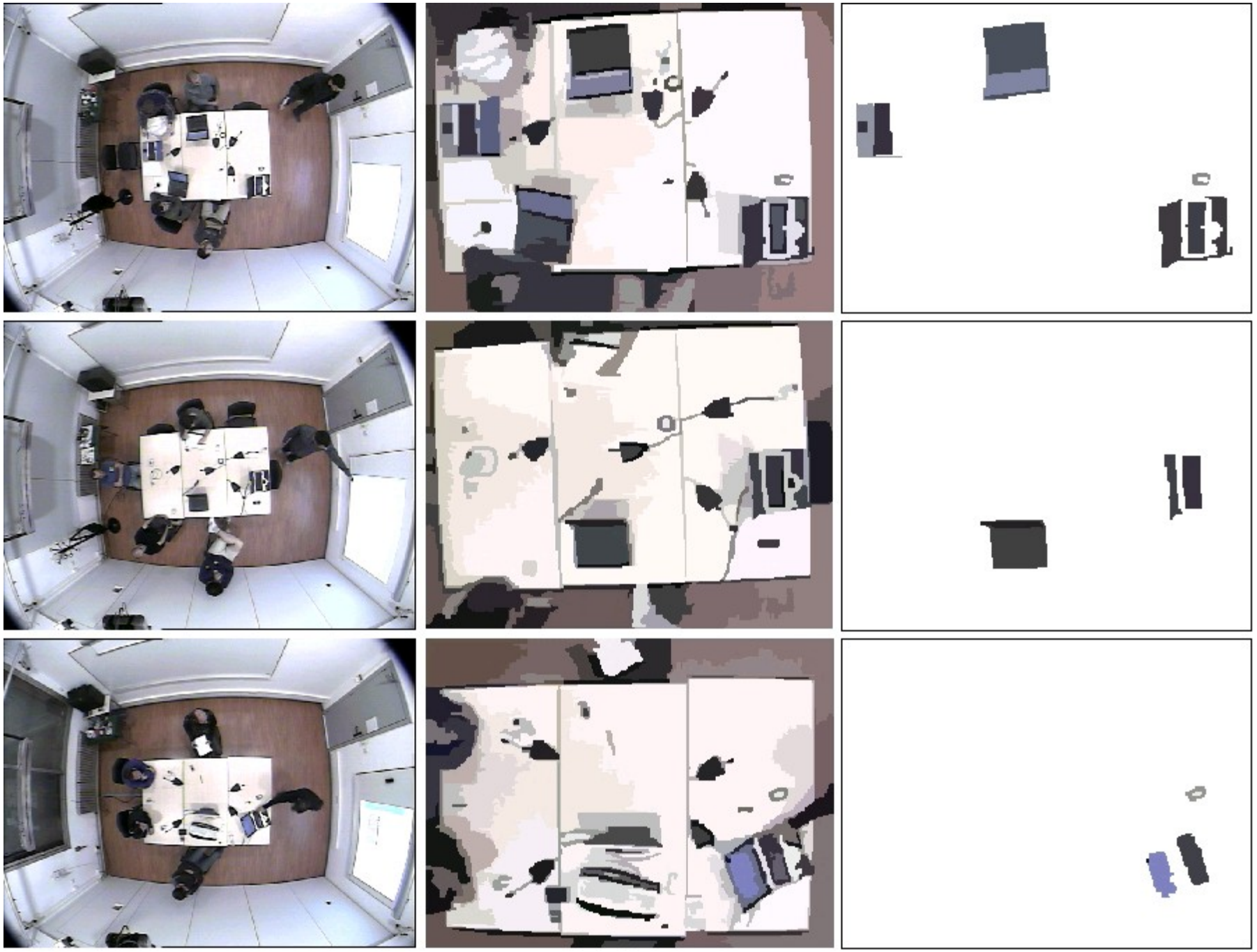
Results: Road-sign detection



Results: Laptop detection (CHIL)



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Conclusions

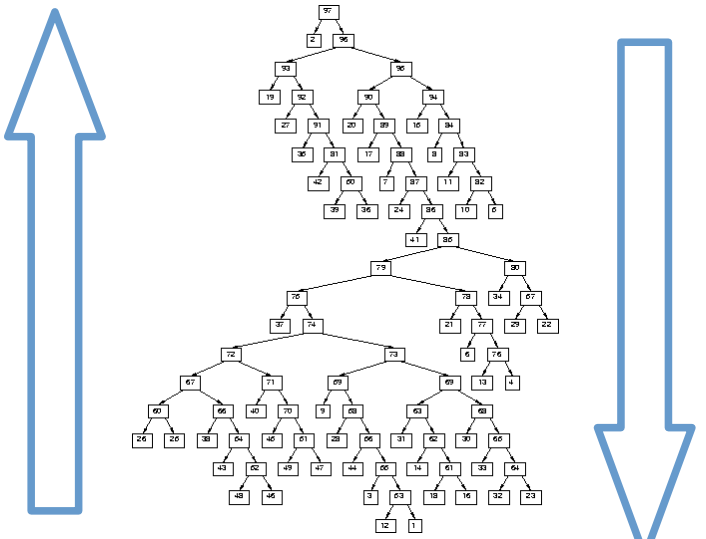
- Two improvements to classic BPT:

BOTTOM-UP (BU)

Syntactic features and combined with statistical analysis (or features) improve BPT creation without introducing any semantic assumption.

TOP-DOWN (TD)

Multiple BPT nodes caused by over-segmentation do not generate multiple instances detection if BPT Semantic Neighbourhood considered.



Enhanced BPT

- Future goals:
  - → Use of decision theory to combine multiple criteria
  - → Semi-supervised model learning.

Thank you

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