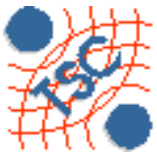

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From Partition Trees to Semantic Trees

Xavier Giró and Ferran Marqués

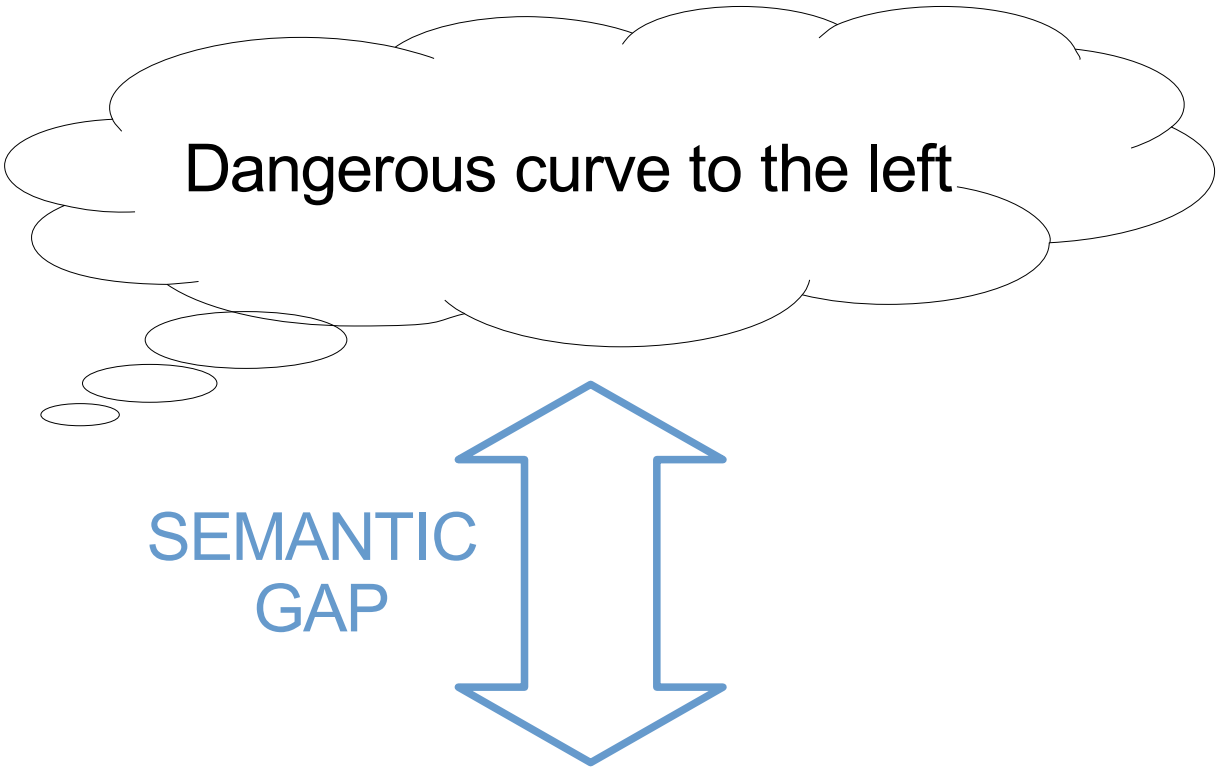
Image Processing Group
Signal & Communications Department
Technical university of Catalonia (UPC)

Outline

1. Introduction ←
2. Image representation
3. Semantics representation
4. Detection algorithm
5. Undirected detection
6. Examples
7. Conclusions

Introduction

- Bridge the semantic gap



Semantics

Perceptual information (visual)

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Image representation

- Colour-based segmentation [5]

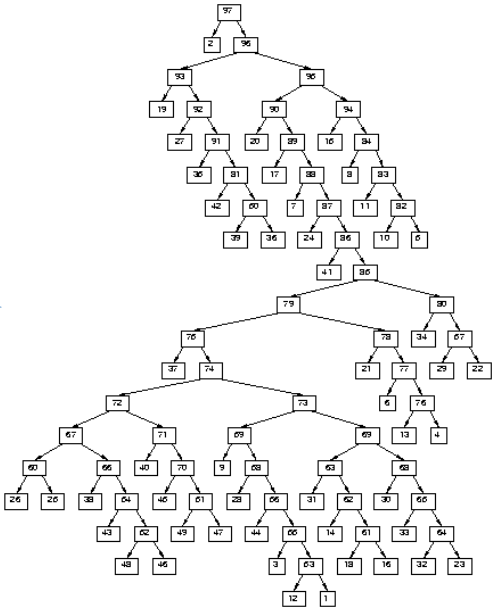
[5] P.Salembier and F.Marqués, “Region-based representations of image and video: segmentation tools for multimedia services”, IEEE Trans. Circuits and Systems for Video Technology (1999).

Image representation

- Binary Partition Tree [6]

Partition

BPT creation



BPT

[6] 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).

Image representation

Example: Colour-based BPT

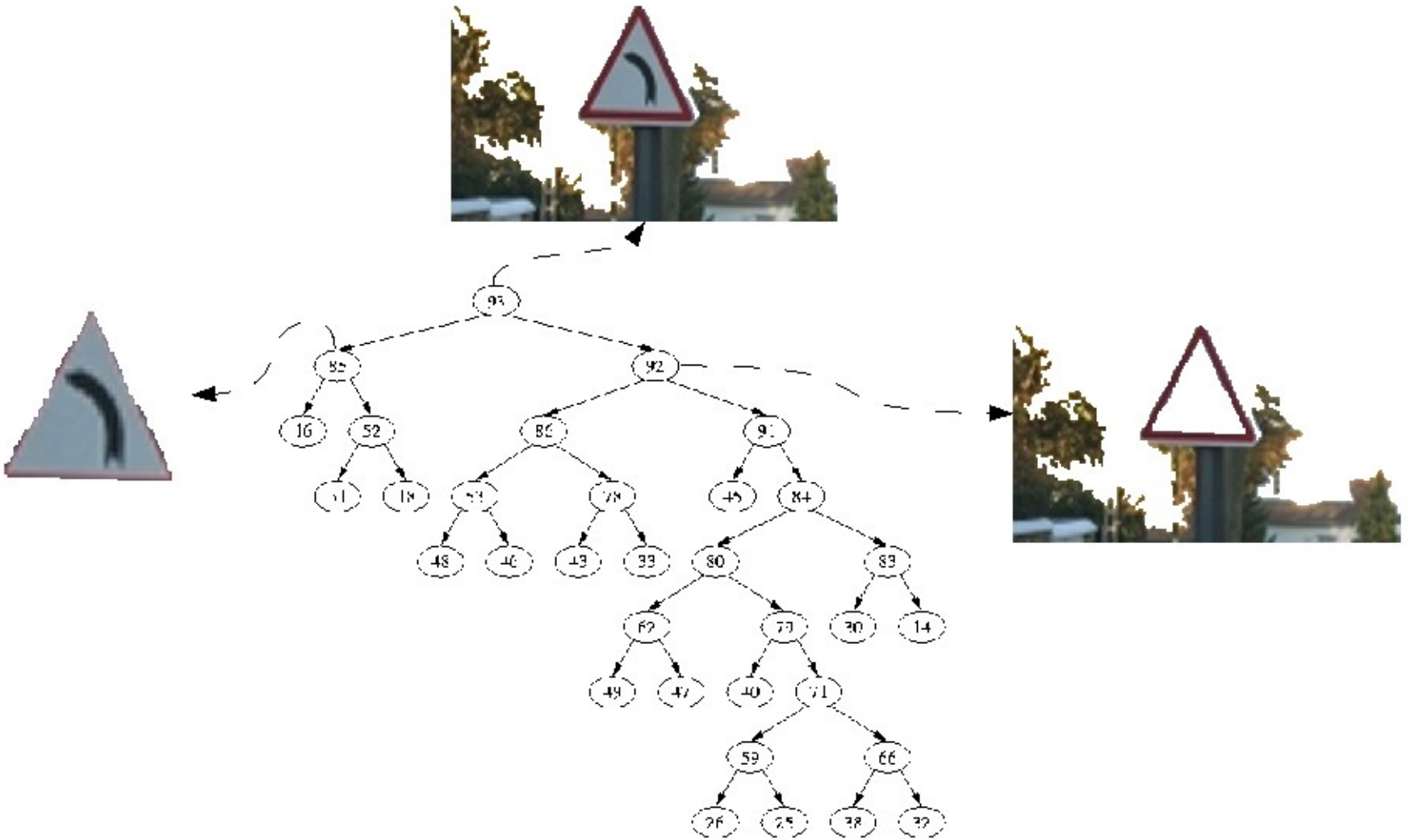


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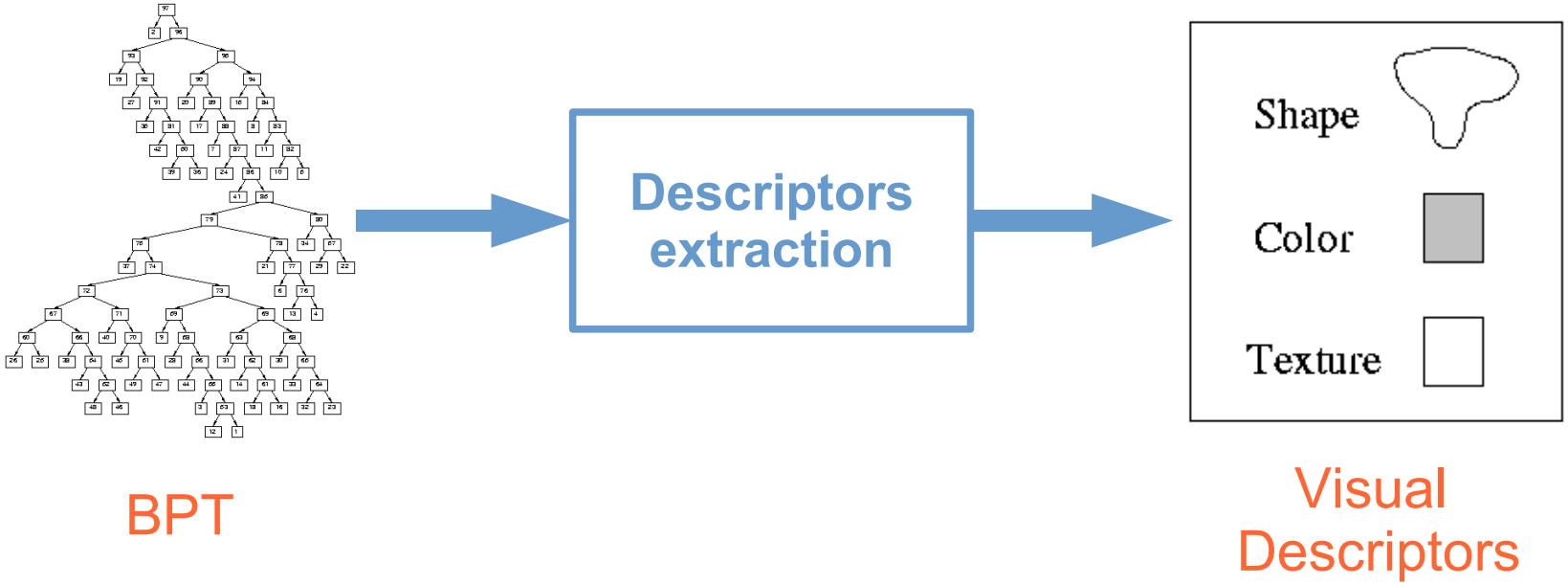
Image representation

- Visual descriptors for each BPT node [7]



[7] V.Vilaplana et al, “Region-based extraction and analysis of visual objects information”, CBMI, Riga, Latvia (2005).

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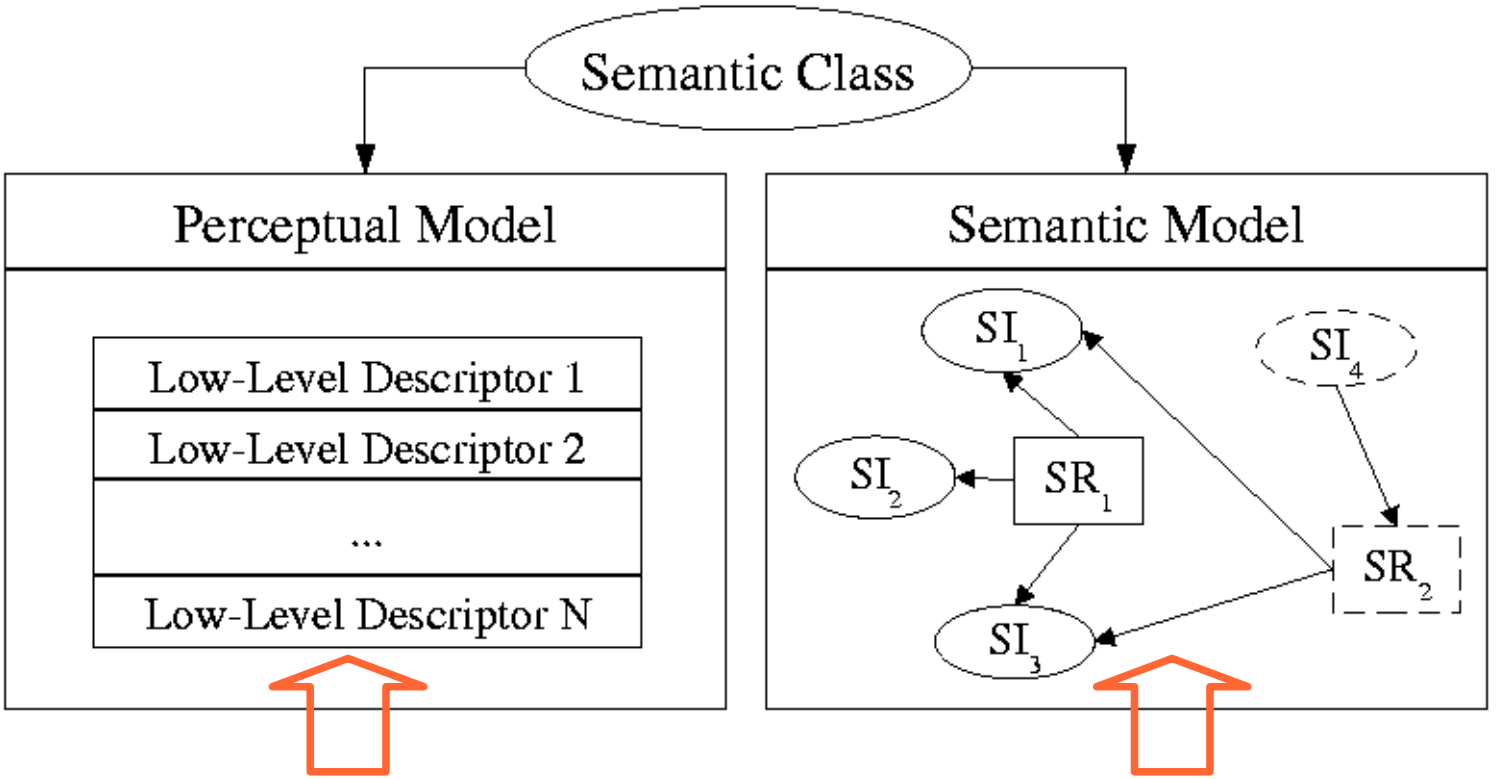
Semantics representation

- Dual model (perceptual and semantic) of Semantic Classes



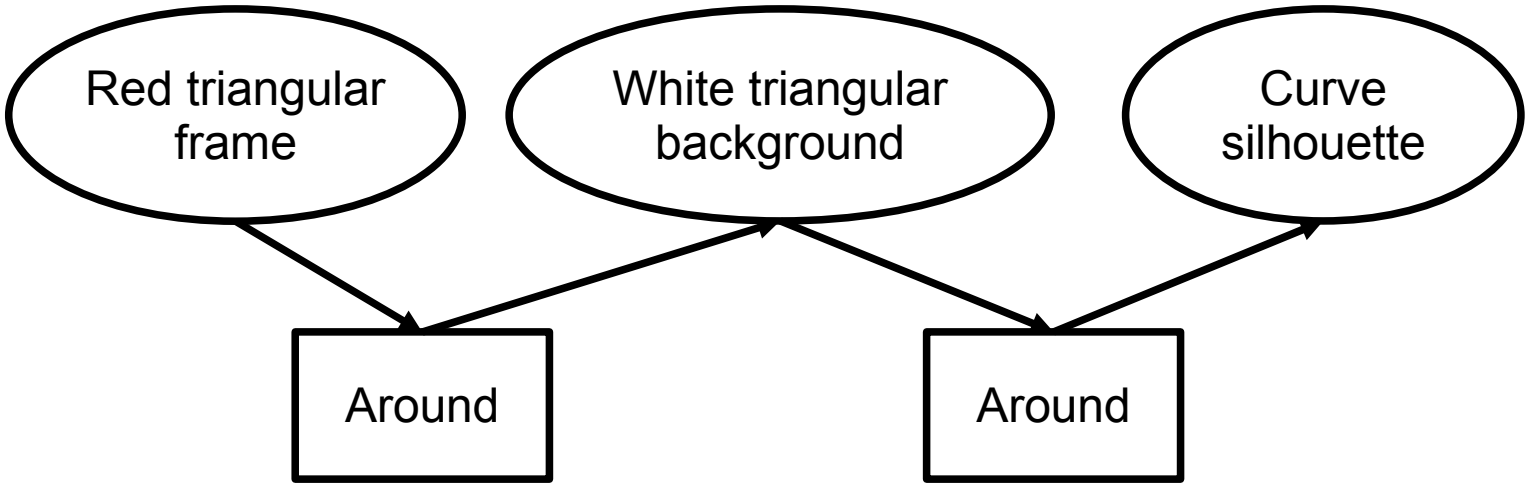
Visual Descriptors (VDs)

Description Graph (DG)

Semantics representation

- Semantic model with Description Graph [9].
- A Description Graph (DG) models a semantic class by assigning semantic instances and their Relations to its vertices.

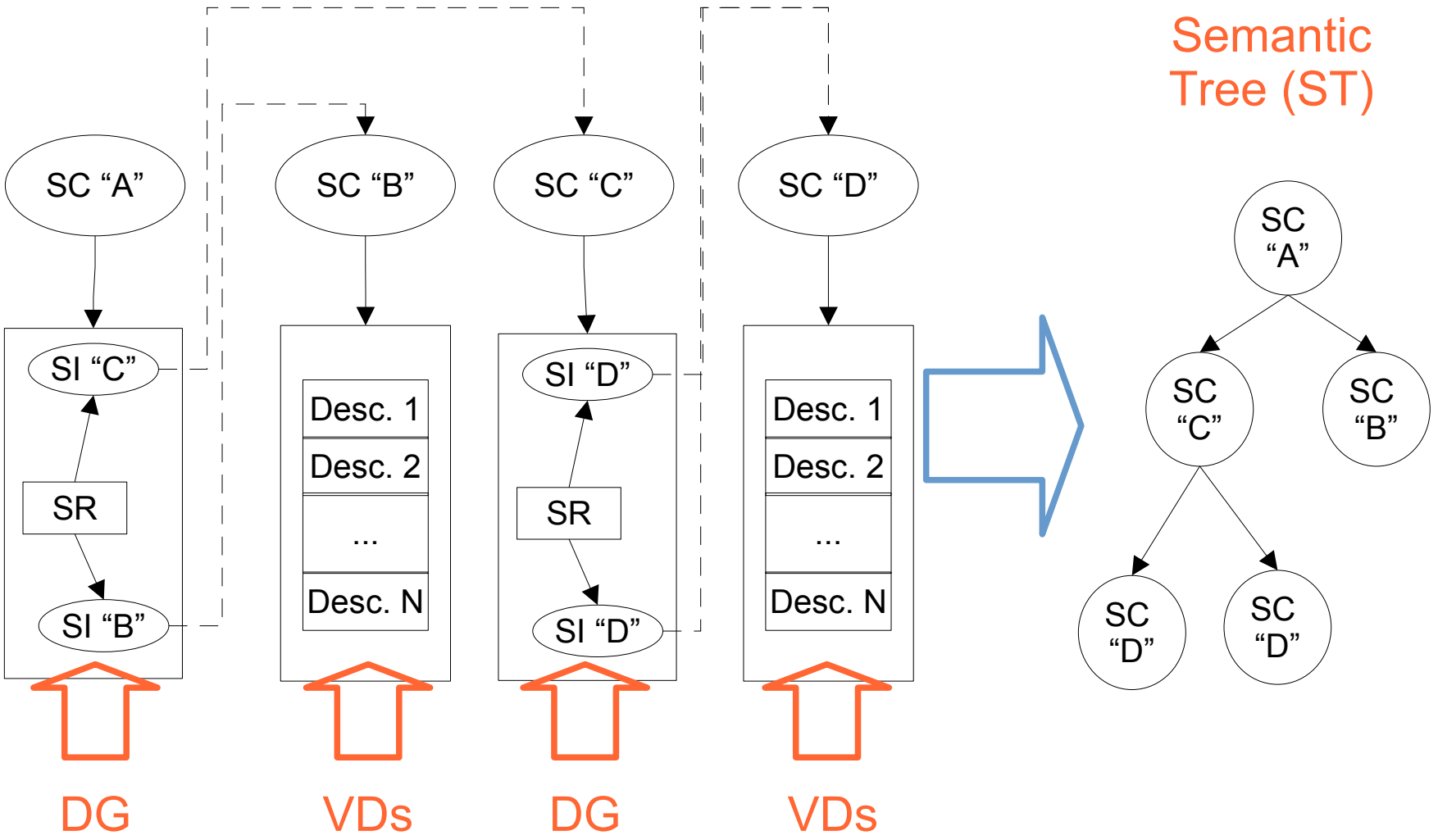
Example: DG of the semantic class "Curve traffic sign"



[9] X.Giró and F.Marqués, "Detection of semantic objects using Description Graphs", ICIP, Genoa, Italy (2005).

Semantics representation

- Hierarchical decomposition in Semantic Trees (STs)



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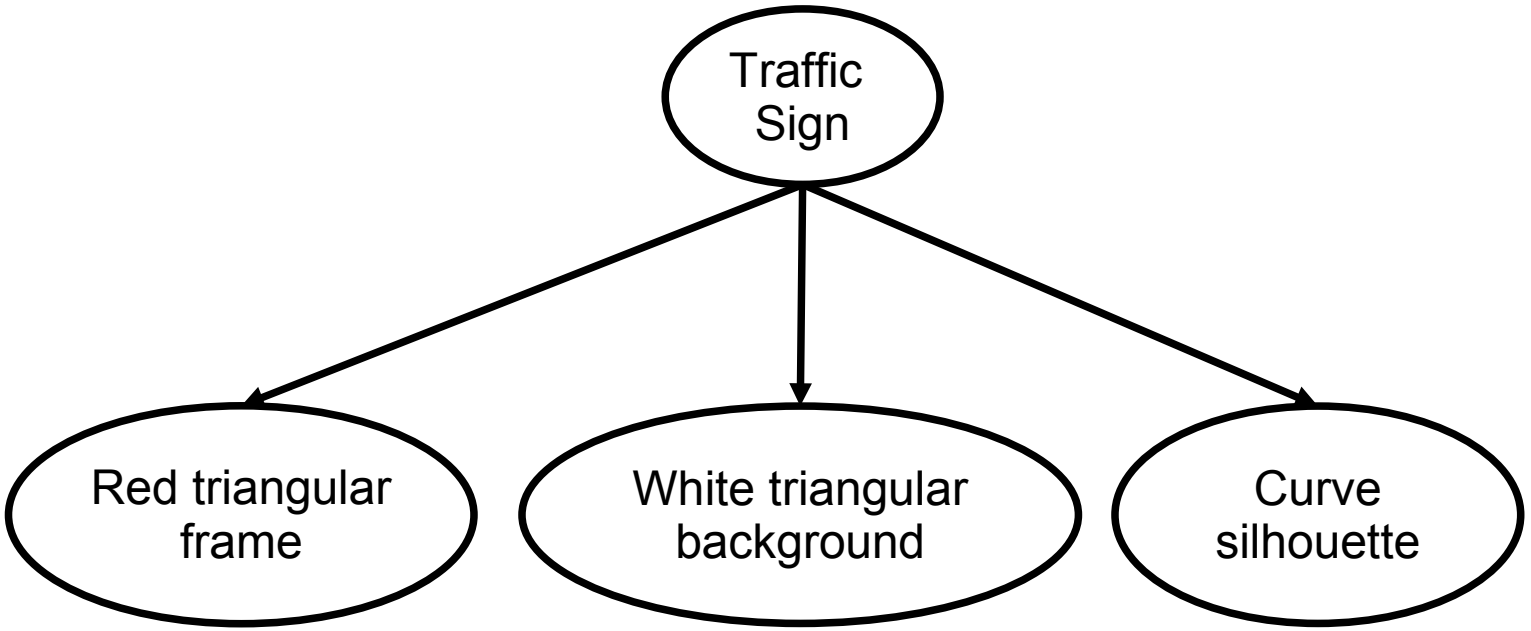
Semantics representation

Example: ST of the semantic class “Curve traffic sign”



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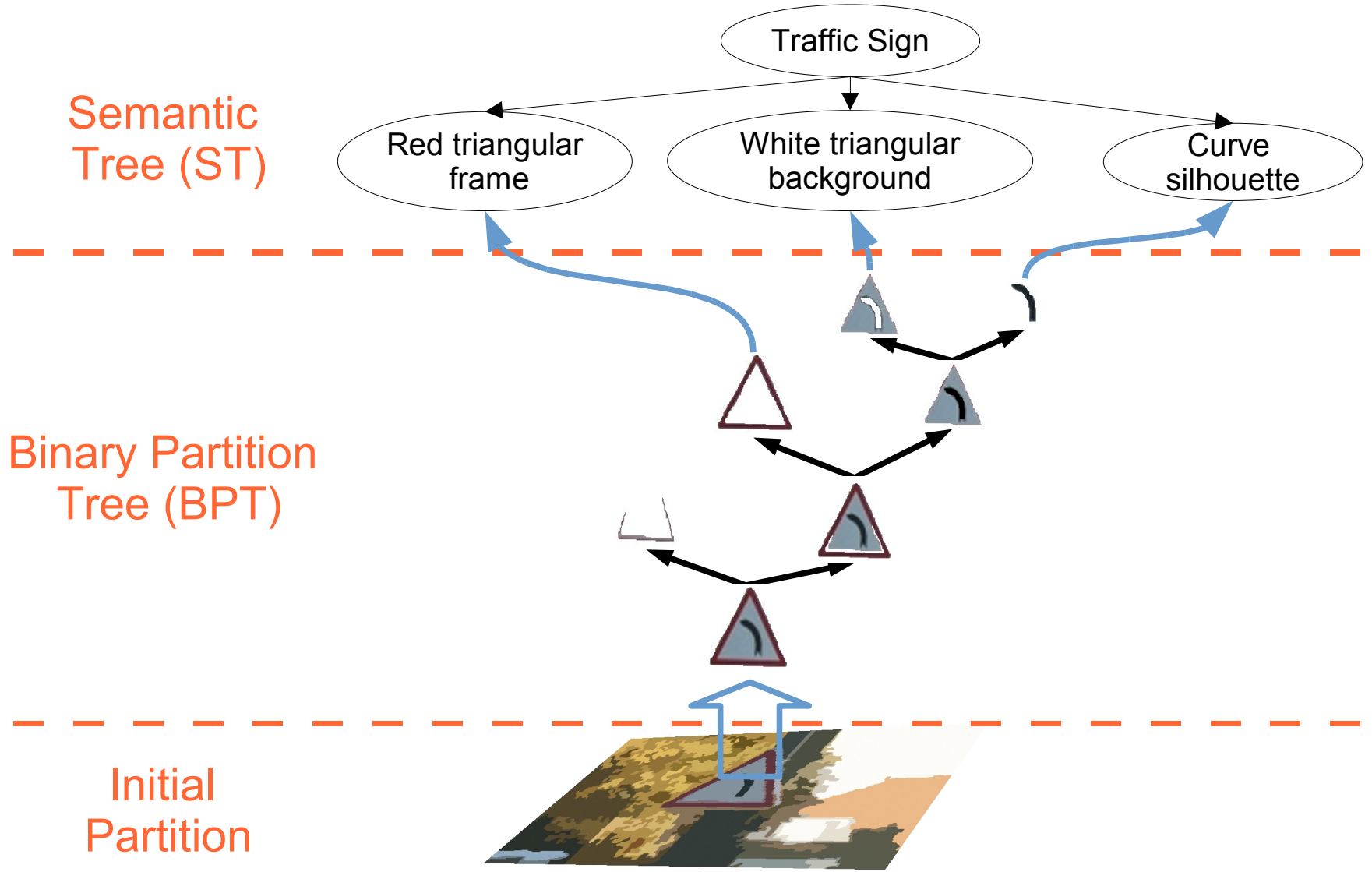
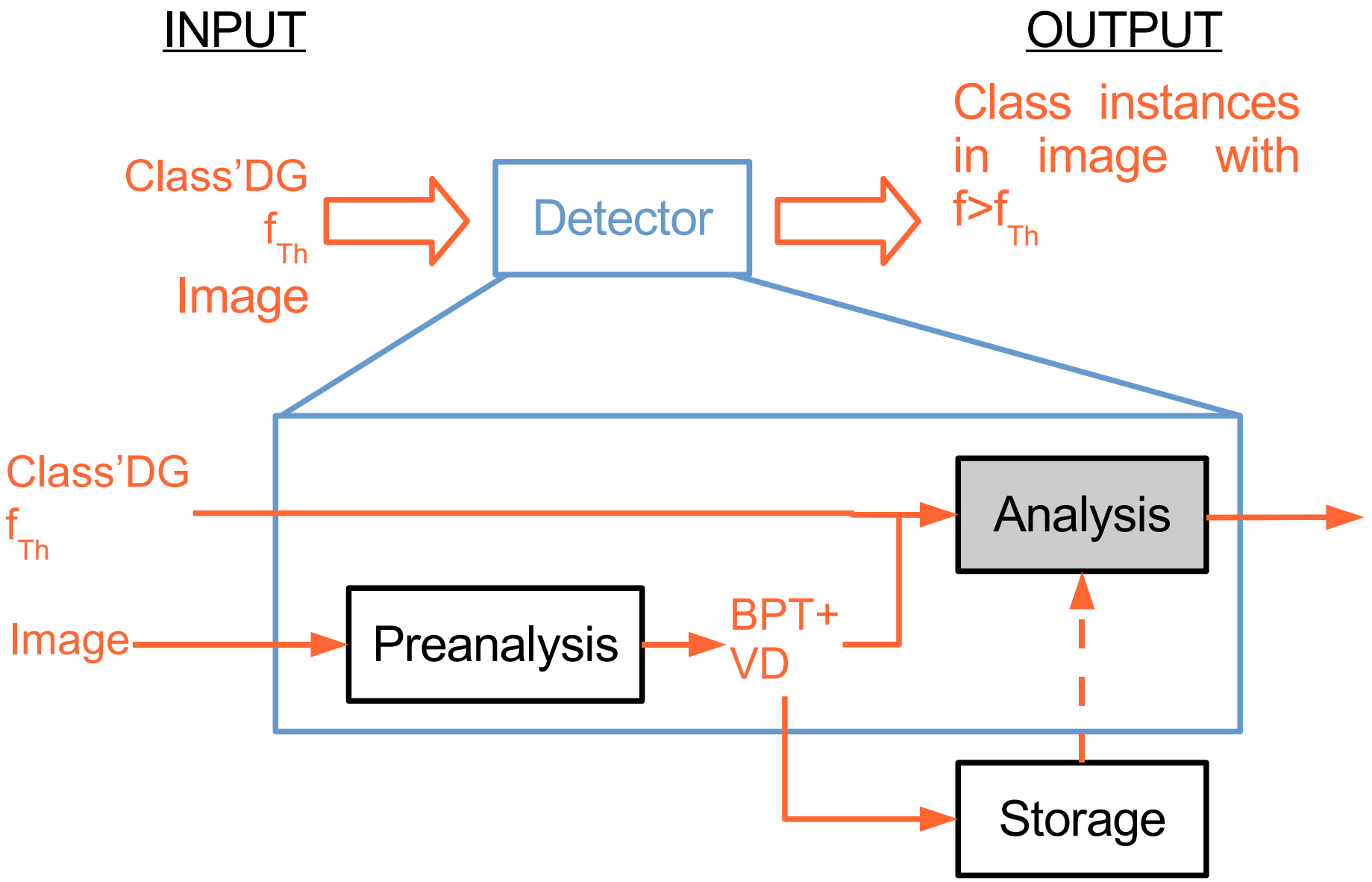
Detection algorithm

- Detection of a given semantic class (top-down approach).
- Detection problem ➔ Building a ST on a BPT.



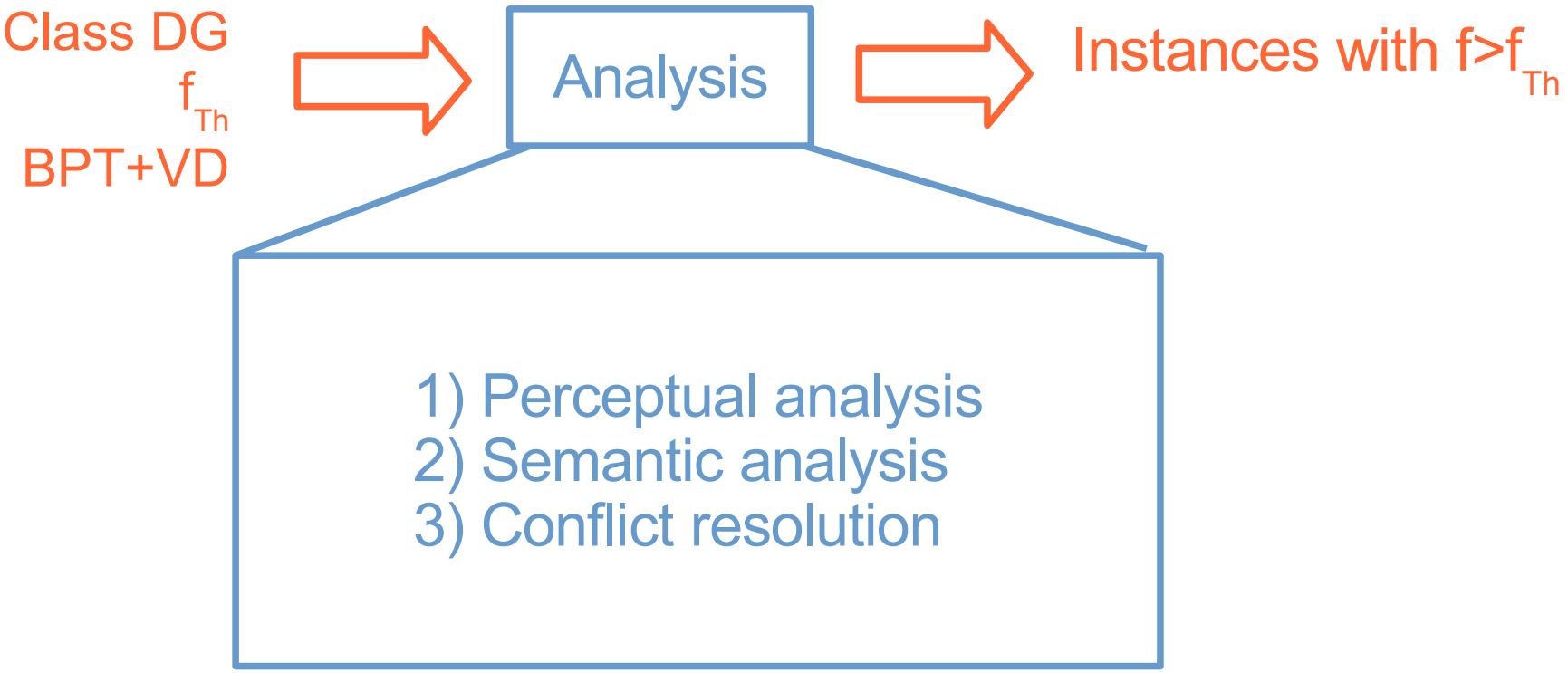
Detection algorithm



- Preanalysis is a generic and costly step.

Detection algorithm

- Analysis is decomposed in 3 basic steps.

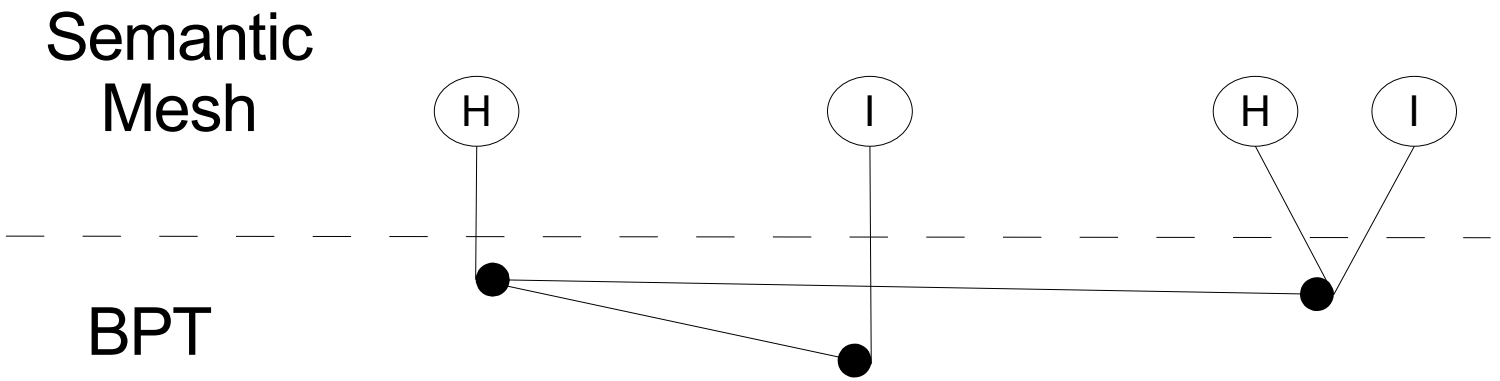


- Only instances composed by BPT nodes can be detected.

Detection algorithm

1) Perceptual Analysis

Example: Detection of classes “H” and “I” based on their perceptual models



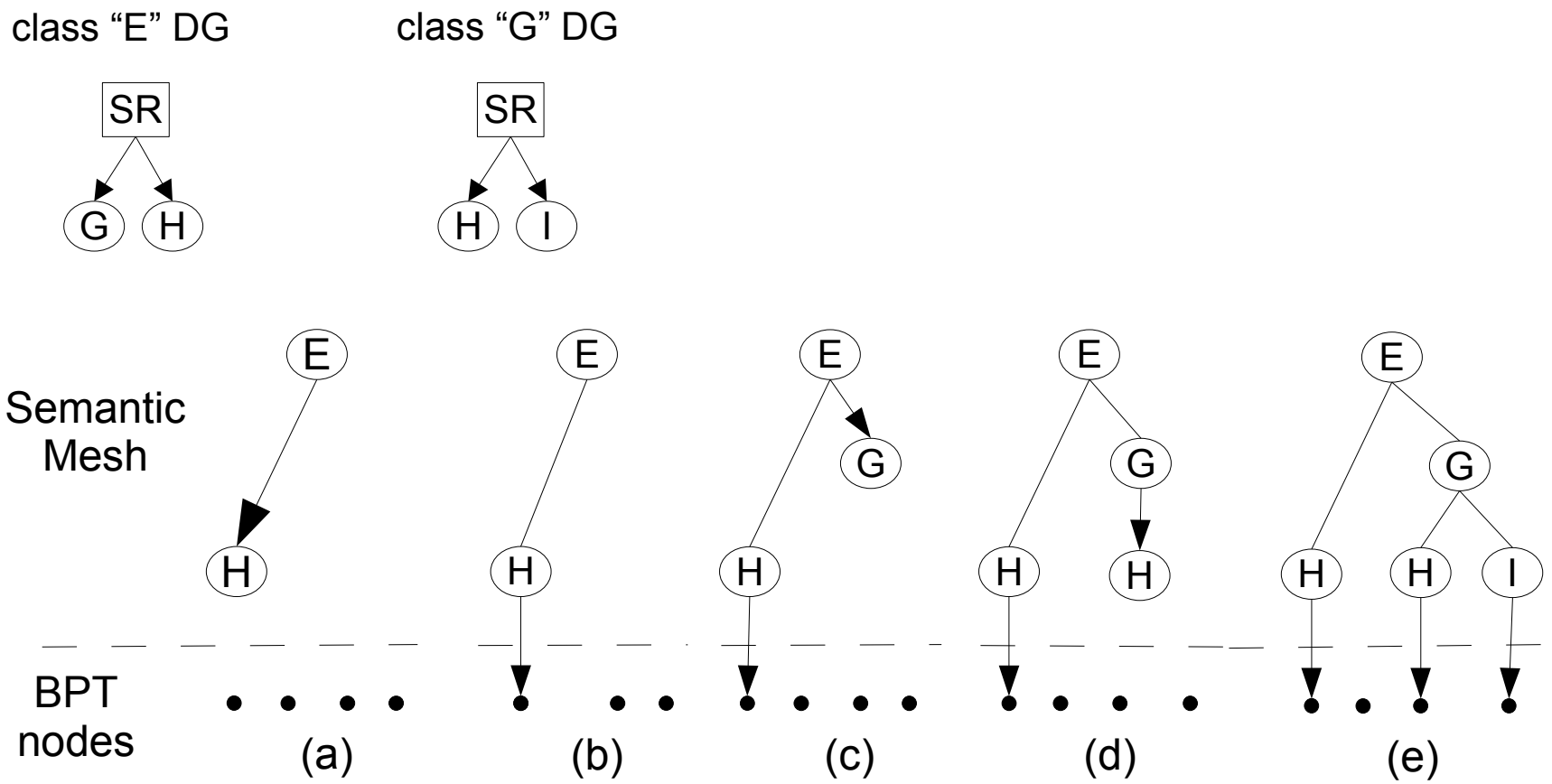
- based on VD similarity
- class-specific detectors may also be used (eg. face).

Detection algorithm

2) Semantic Analysis

- Top-down semantic expansion

Example: Detection of class "E" based on its semantic model



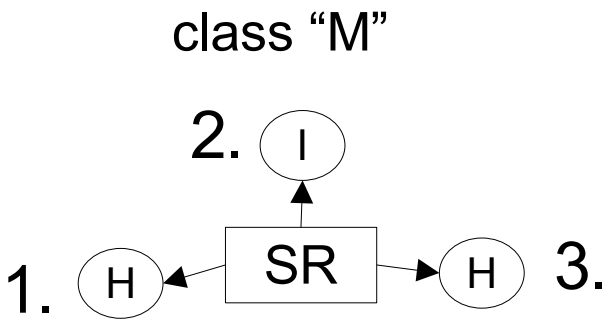
Detection algorithm

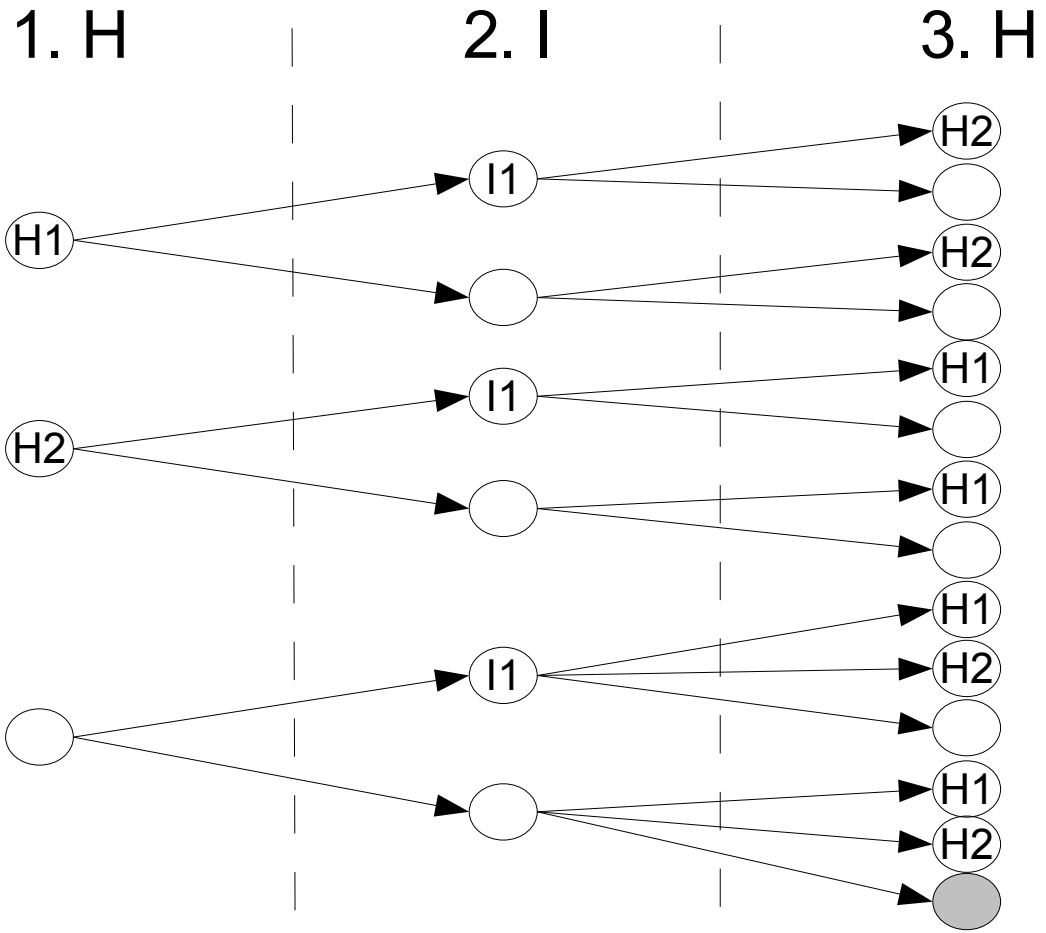
2) Semantic Analysis

- Graph matching between DG nodes and ST nodes in the mesh.

Semantic Mesh

Description Graph





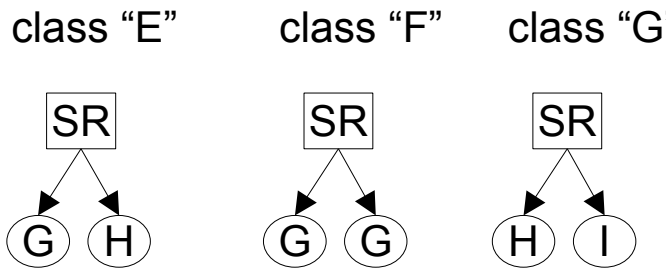
Detection algorithm

2) Semantic Analysis

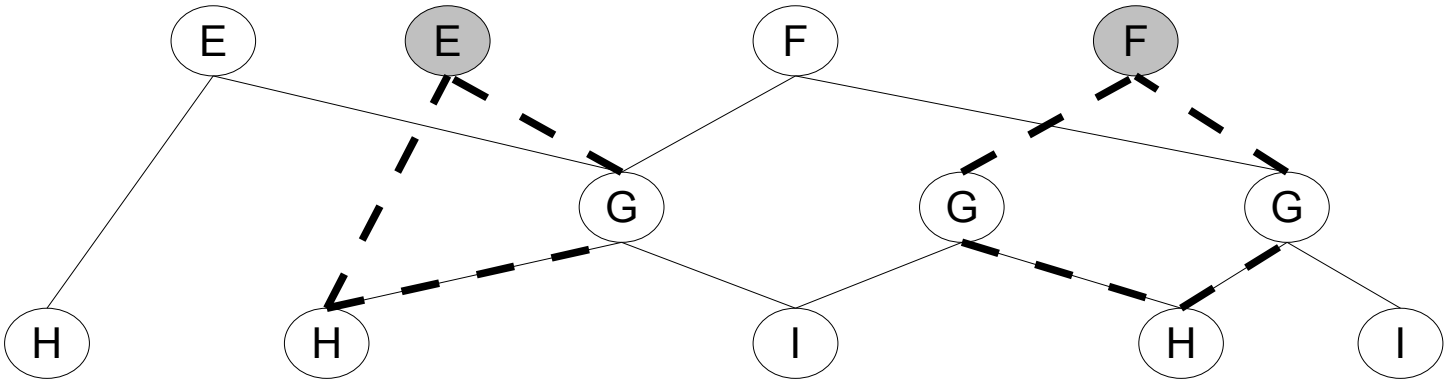
- Discard matchings that create cycles through the Mesh.
- A cycle is created when a single instance is multiply considered in the same higher semantic instance (eg. one shoe as part of two different legs for the same person).

Example: Refusal of two nodes (in grey)

Description Graphs



Semantic Mesh



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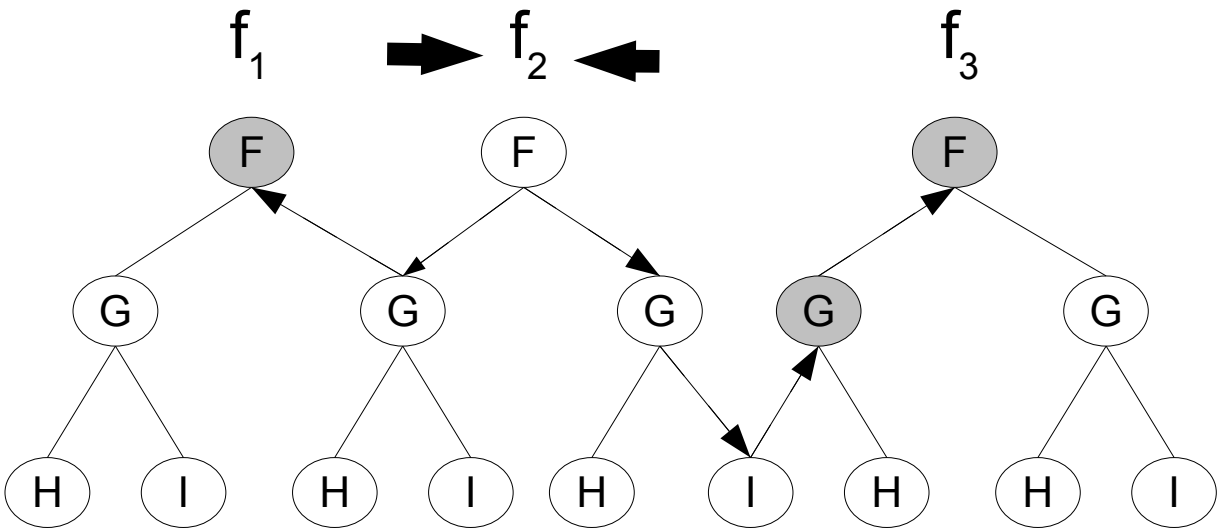
Detection algorithm

3) Conflict resolution

- Each ST node can only sustain one ST node.
- Otherwise, one single instance would be part of more than one higher semantic instance (eg. 1 mouth for 2 faces)
- Keep the highest and most confident node if conflict.

Example: Conflict resolution among three potential instances of class “F”.

Semantic Mesh



$$f_2 > f_1 > f_3$$

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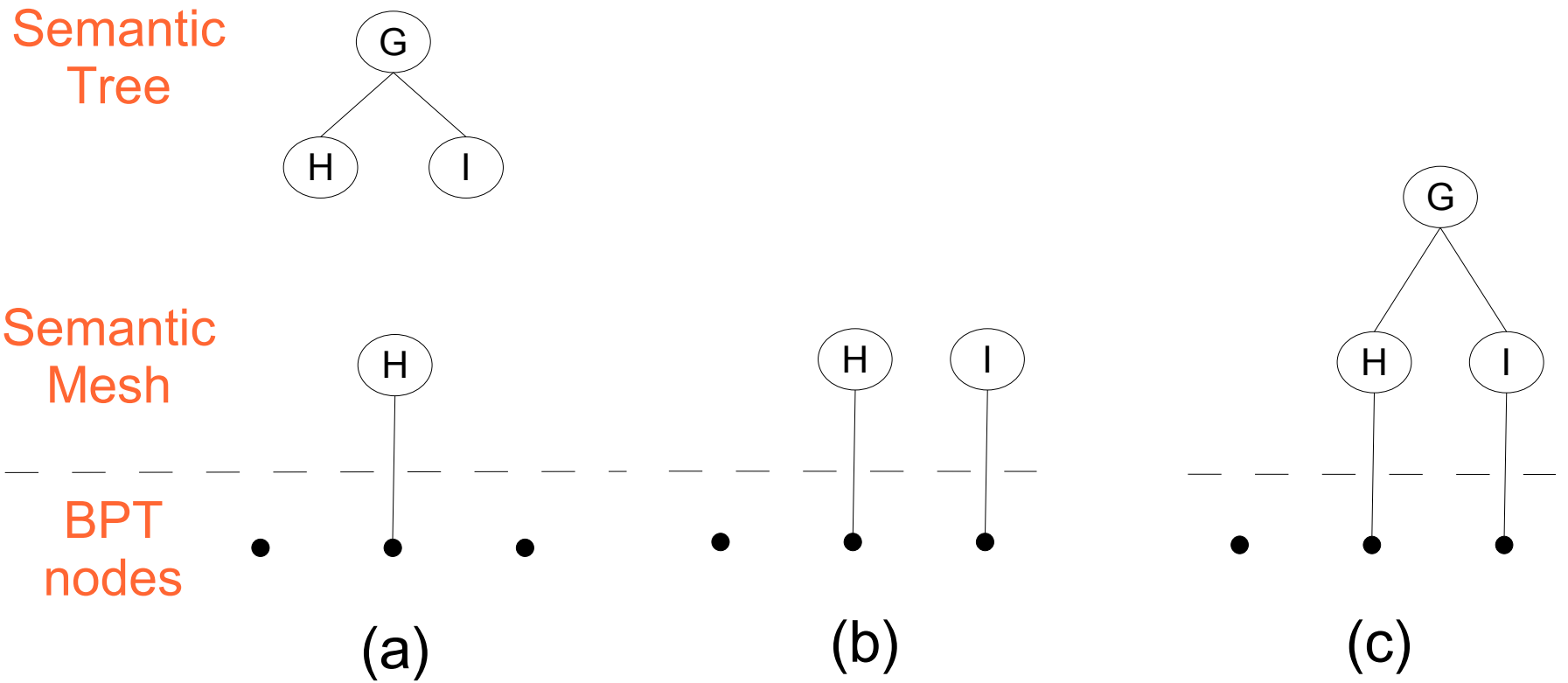
Undirected detection

- If no previous knowledge about which class to detect, an exhaustive perceptual analysis with all models in the database may launch a bottom-up semantic expansion.

Example: Undirected detection of class “G”



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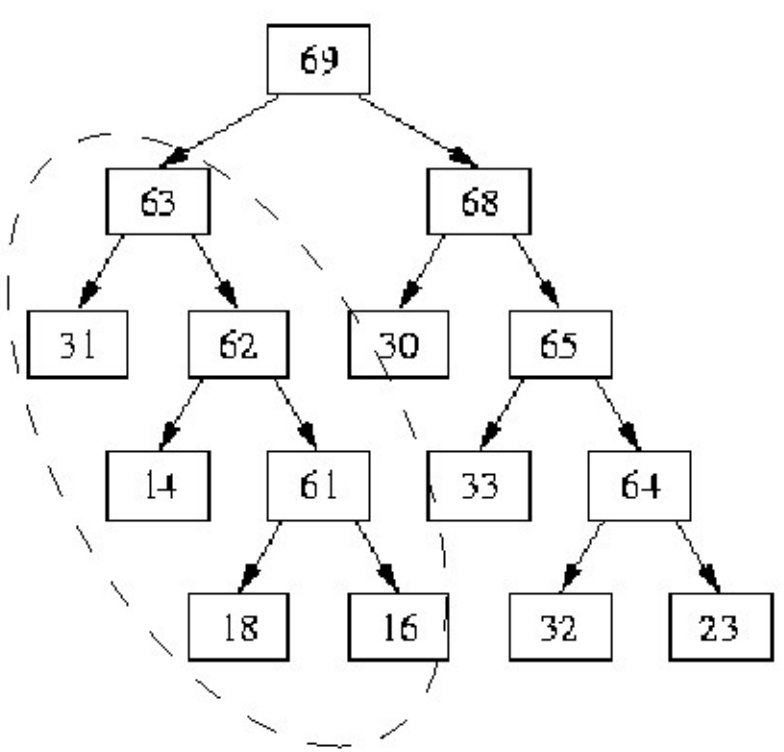
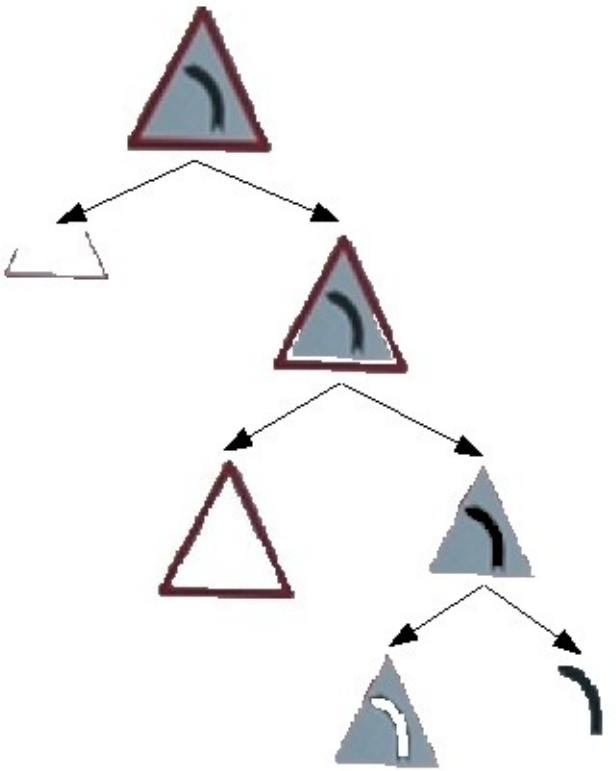
Examples

Example: Syntactic-based BPT [15]



(a)



(b)

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

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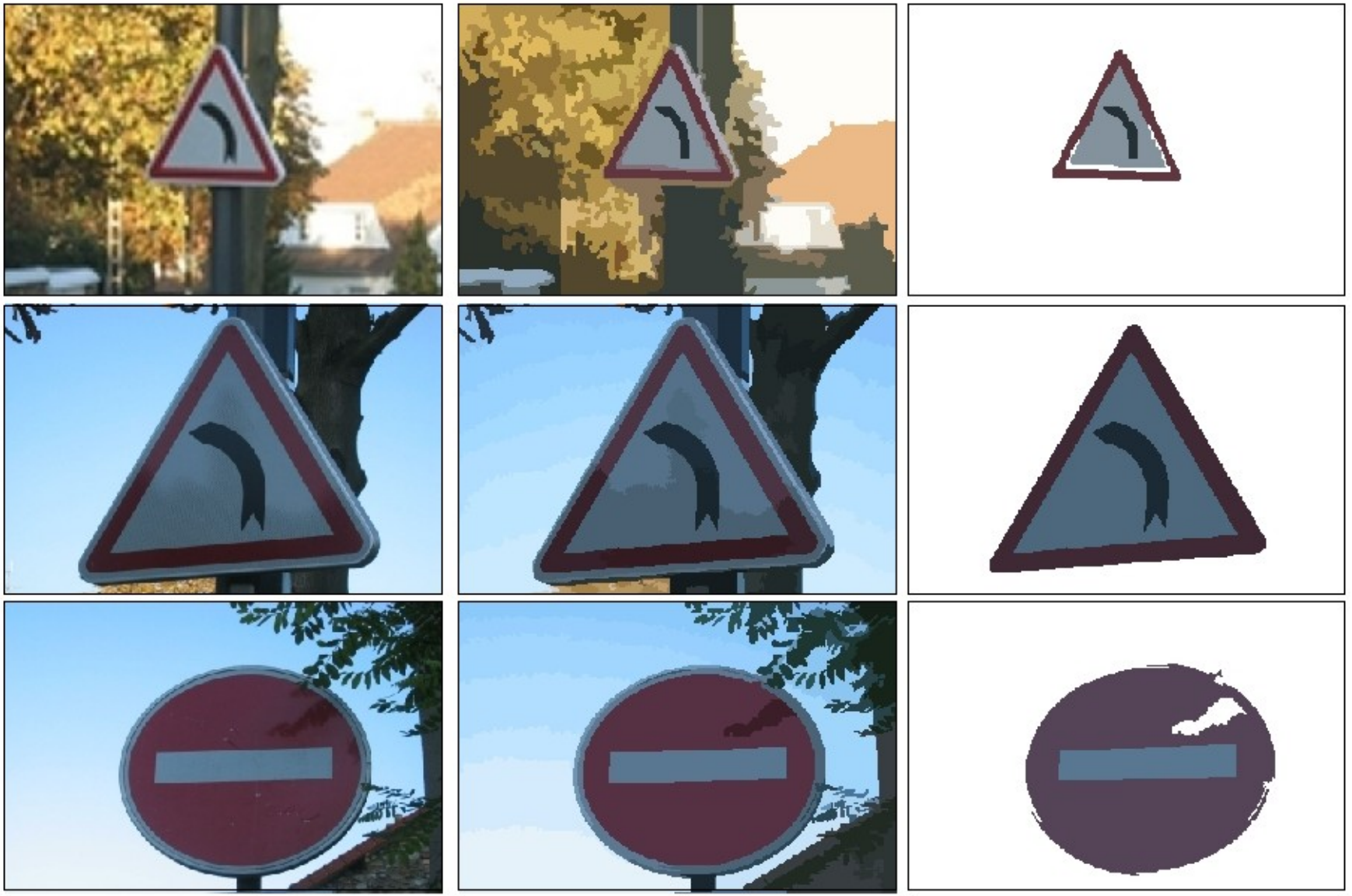
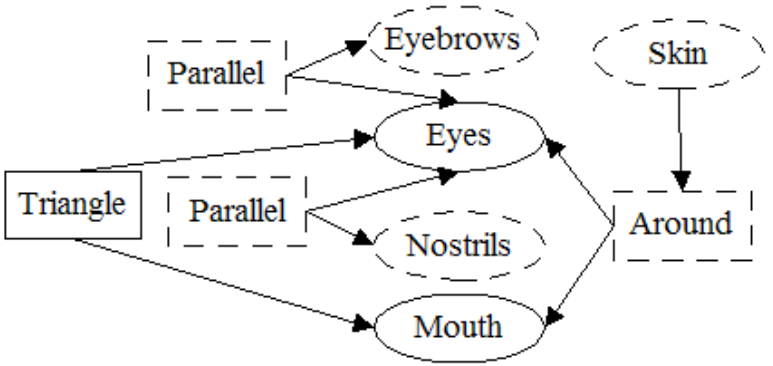
Examples



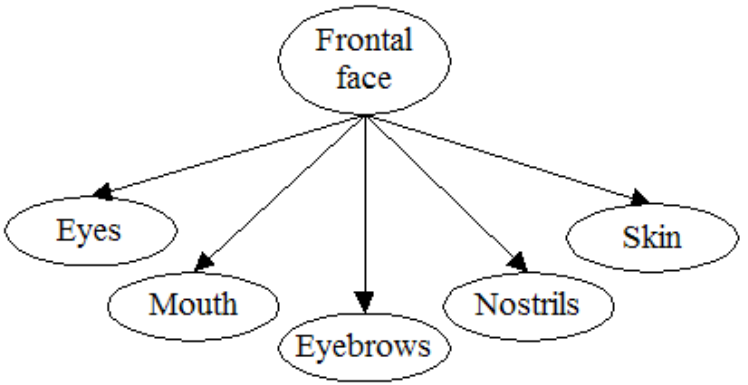
Examples

Semantic class: Frontal face

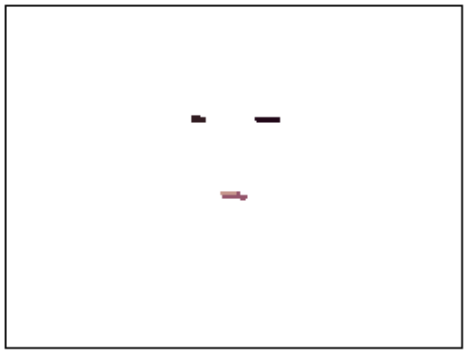
DG



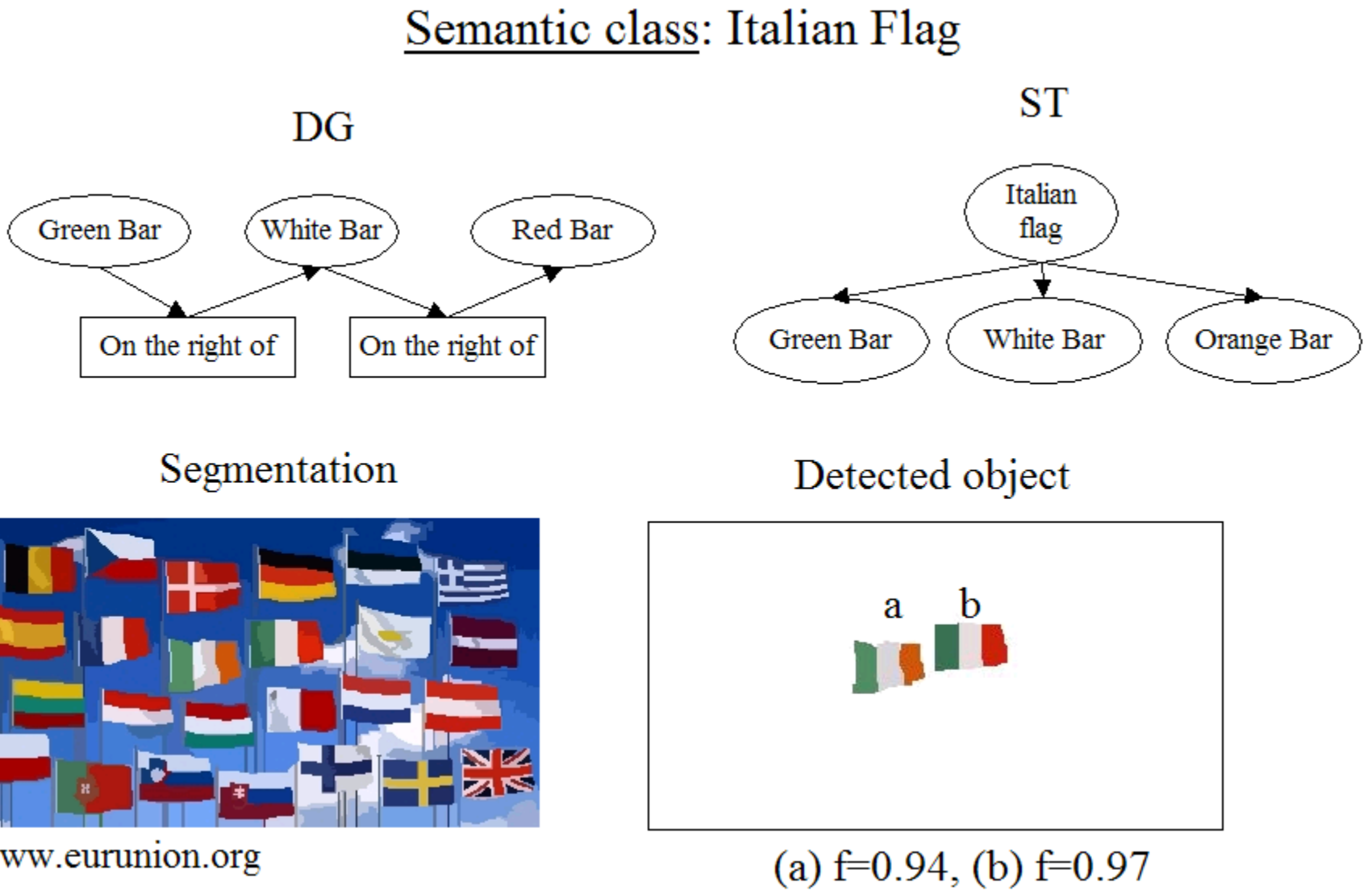
ST



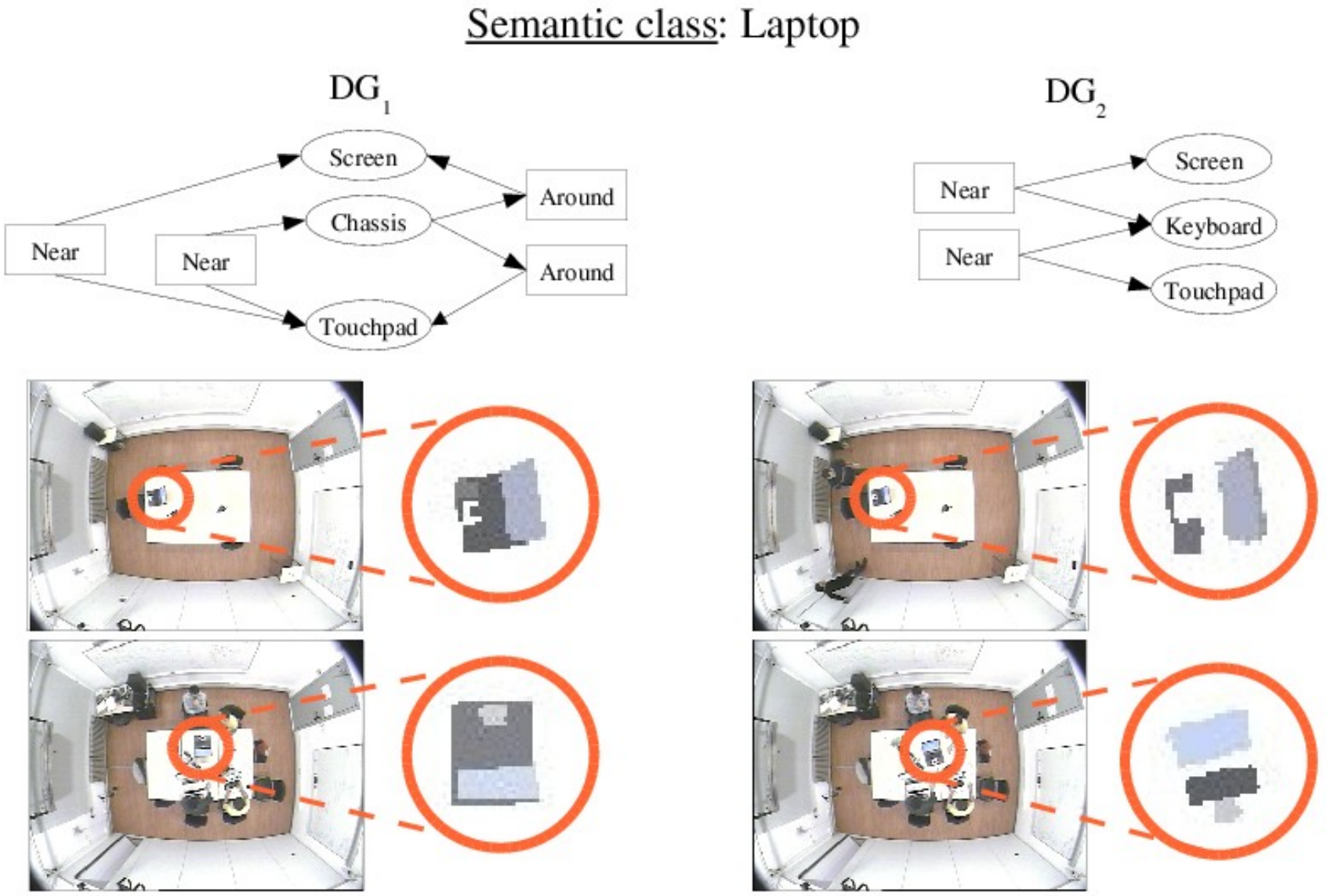
Segmentation | Detected object | Segmentation | Detected object

Examples


Semantic class: Italian Flag
DG
Green Bar
White Bar
Red Bar
On the right of
On the right of
ST
Italian flag
Green Bar
White Bar
Orange Bar
Segmentation
Detected object
a
b
www.eurunion.org
(a) f=0.94, (b) f=0.97

Examples


Semantic class: Laptop
DG1
Screen
Chassis
Touchpad
Near
Near
Around
Around
DG2
Near
Near
Screen
Keyboard
Touchpad

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Conclusions

- Generic approach.
- Stored preanalysis (BPT+VD) allows fast semantic retrieval.
- Human-intuitive semantic models (Description Graphs) with direct application to analysis algorithms.
- Description Graphs introduce context in analysis.
- Performance depends on models accuracy.
- Future work:
  - Fusion of SVMs feature detectors in perceptual analysis.
  - Semi-supervised semantic models creation.
  - Evaluation with annotated databases (TRECVid, ImageEval, CHIL ?)

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