BPT Enhancement Based on Syntactic and Semantic Criteria

C. Ferran, X. Giró, F. Marqués and J. R. Casas
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

![Dangerous curve to the left](image)

**SEMANTIC GAP**

Perceptual information (visual)

Semantic objects
Introduction

[1] Colour-based segmentation

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

**Introduction**

[2] Binary Partition Tree creation

- **Assumption**: BPT nodes (or combinations of them) represent all semantic objects

[3] Syntactic Tree creation

- **Aim**: improve the initial segmentation using generic syntactic criteria so that most BPT nodes (or combinations of them) represent all semantic objects


X.Giró et al.,“BPT Enhancement based on Syntactic and Semantic Criteria” - 08/12/2006 @ SAMT, Athens, Greece
Introduction

[4] Semantic Tree creation

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

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Enhanced BPT

Two improvements to classic BPT:

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

**TOP-DOWN (TD)**
Introduction of BPT Semantic Neighbourhood during BPT analysis.
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Syntactic BPT creation (BU)

BPT creation algorithm

I → Simplification → Feature Extraction → Decision → P^{N-k}(I)

Pixels → Regions → Features → BPT

Image → Initial Partition → Feature Space

N Regions → C_B

x

x

x

x

Feature Space → C_A

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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

\[ d = f(\text{Entropy}, \text{Dissimilarity}) \]
Example: Color-based BPT
Example: Syntactic-enhanced BPT
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**Goal:** Analyse BPT and build a Semantic Tree on it.

**Semantic Tree (ST):**
- Traffic Sign
  - Red triangular frame
  - White triangular background
  - Curve silhouette

**Binary Partition Tree (BPT):**
- Initial Partition
Neighbour BPT nodes may have similar perceptual features

Problem: Multiple detections of a single instance.

Example: BPT nodes representing laptop screen and keyboard

Which ones to choose?
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”
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)

Which ones to choose?

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.
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

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Results: Road-sign detection

(a)

(b)

(c)
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.

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