Supervised Evaluation of the Quality of Binary Partition Trees based on Uncertain Semantic Ground-Truth for Image Segmentation Purpose

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**Binary Partition Tree (BPT)**
Hierarchical representation of an image based on a metric / feature choice

**Problemsatics**
Is the BPT "good"?

How to evaluate?

How to chose a good metric / feature to build a BPT?

**1-GT Map Choice**
User

Problem of Uncertain borders

Image

Semantic labels

Built area

Forest area

Herbeceous area

Shadow

GT map

**2- Node / Segment Matching**
Comparing a node N and a GT segment S

Similarity metric \( \Lambda(S, N) \)

Examples of the function \( \Lambda \)

Jaccard: \( J(N, S) = \frac{\text{Built area}(N) \cap \text{Built area}(S)}{\text{Built area}(N) \cup \text{Built area}(S)} \)

Dice: \( D(N, S) = \frac{2 \text{Built area}(N) \cap \text{Built area}(S)}{\text{Built area}(N) + \text{Built area}(S)} \)

Distance function

Membership function

Uncertainty model

\( TP(N, S) = \sum_{x \in S} \mu_{\text{Built area}}(x) \text{dx} \)

\( FP(N, S) = \sum_{x \notin S} (1 - \mu_{\text{Built area}}(x)) \text{dx} \)

\( TP(N, S) = \sum_{x \in S} (1 - \mu_{\text{Built area}}(x)) \text{dx} \)

\( FP(N, S) = \sum_{x \notin S} \mu_{\text{Built area}}(x) \text{dx} \)

\( \mu_{\text{Built area}}(x) = \frac{\text{Built area}(x)}{\text{Built area}(S)} \)

**3- Finding Matching Nodes**

Nodes matching in the BPT

GT segments

Spatial constraints

Vertical selection

Quantitative heuristics

Horizontal selection

**4- Global Quality Score**

For each \( S_i \)

Best matching node

Average global score

For the GT map composed of \( S \)

Best similarity score

Weighted global score

with \( w_i = 1 \), \( \sum_{i \in S} w_i = 1 \), and \( w_i \geq 0 \) where \( S \) is the label set and \( C \) is the different semantic classes of GT segments

**Experiments and Results**

<table>
<thead>
<tr>
<th>Image</th>
<th>GT</th>
<th>Std</th>
<th>NDVI</th>
<th>NDWI</th>
</tr>
</thead>
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<table>
<thead>
<tr>
<th>Index</th>
<th>Std</th>
<th>NDVI</th>
<th>NDWI</th>
<th>N/S</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D )</td>
<td>0.670</td>
<td>0.523</td>
<td>0.516</td>
<td>51/51</td>
<td>450</td>
</tr>
<tr>
<td>( J' )</td>
<td>0.531</td>
<td>0.389</td>
<td>0.399</td>
<td>51/51</td>
<td>484</td>
</tr>
</tbody>
</table>

Global quality scores of \( BPT_{\text{std}}, BPT_{\text{ndvi}} \) and \( BPT_{\text{ndwi}} \) from a VHRS image (1000x1000 pixels). \( N/S \): number of BPT nodes retrieved according to the number of reference segments.

**Keywords**

- Binary Partition Tree (BPT)
- Supervised evaluation
- Uncertainty
- Semantics
- Segmentation
- Mathematical morphology
- Remote sensing

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