Context-Based Energy Estimator: Application to Object Segmentation on the Tree of Shapes

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Demo available at http://olena.lrde.epita.fr/ICIP2012

Main Contributions

- Novel efficient ratio-cut estimator:
  - well suited to characterize object contours;
  - integrates some contextual information.
- Fully automated approach to retrieve the significant objects:
  - no need for prior knowledge on the number of objects;
  - produces a saliency map representing the meaningfulness of objects.

Effective results

- Segmented objects.
- Saliency map.
- Segmented objects.
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Context-based energy estimator

For a given image \( u \) and a curve \( \partial\tau \) (contour of a region \( \tau \), composed of pixel edges \( e \)), the energy estimator is defined by:

\[
E(u, \partial\tau) = \alpha E_{\text{int}}(u, \partial\tau) + E_{\text{ext}}(u, \partial\tau) + \beta E_{\text{con}}(u, \partial\tau)
\]

Internal energy: smoothness of the contour \( \partial\tau \):

\[
E_{\text{int}}(u, \partial\tau) = \sum_{e \in \partial\tau} |\text{curvature}(u)(e)| / L(\partial\tau)
\]

Constraint energy: constraint to avoid small objects,

\[
E_{\text{con}}(u, \partial\tau) = 1 / L(\partial\tau)
\]

External energy: significance of the contour \( \partial\tau \) regarding to its context,

\[
E_{\text{ext}}(u, \partial\tau) = V(u, \mathcal{R}_{\text{int}}(\partial\tau)) + V(u, \mathcal{R}_{\text{ext}}(\partial\tau))
\]

\[
V(u, \mathcal{R}) = \sum_{p \in \mathcal{R}} (u(p) - \pi(\mathcal{R}))^2
\]

For each image \( u \) and curve \( \partial\tau \) in the image, the energy \( E(u, \partial\tau) \) can be computed by the following process:

1. **Tree construction** [1]: quasi-linear complexity based on union-find process.
2. **Energy computation**: incremental computation during the tree construction.
3. **Morphological filtering on the tree** [2]: tree with nodes weighted by energy \( \Rightarrow \) nodes weighted graph. Morphological closing removes meaningless minima.
4. **Resistant minima** \( \Rightarrow \) meaningful objects.
5. **Selection of segmented objects**: weight each minima (so the corresponding objects) by the filtering force at which this minimum vanishes \( \Rightarrow \) saliency map.

References