RIGOR: Reusing Inference in Graph Cuts for generating Object Regions

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» CODE available   http://cpl.cc.gatech.edu/projects/RIGOR

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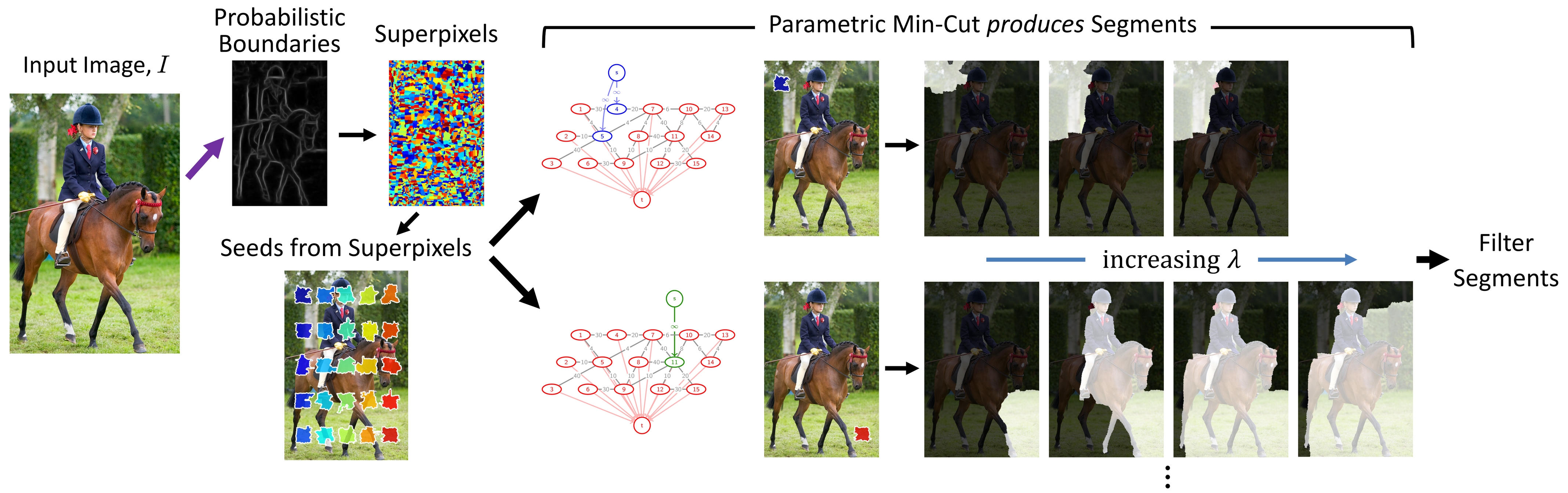
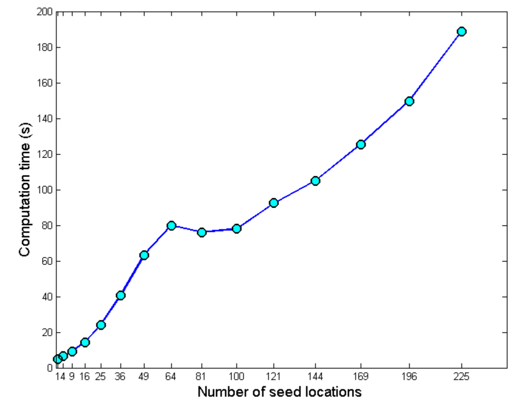
Goal: Generate unsupervised multiple *figure-ground segmentations*, in an order of magnitude faster than the state-of-art, without loss of accuracy.

Method Overview: Our algorithm has the following stages:

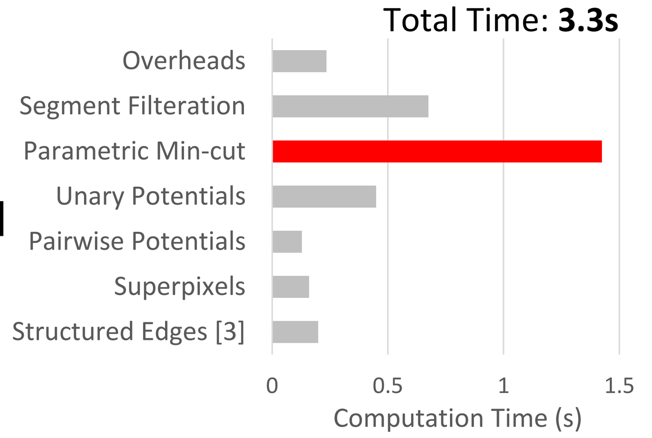


Fact 1
More seed locations gives higher recall

Fact 2
Obtaining segments from more seed locations is slow

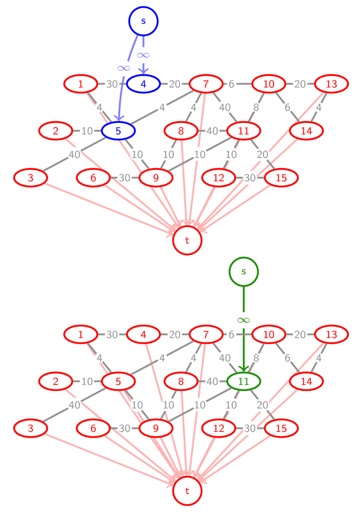


Fact 3
PMC takes 45% of the total time after all other improvements (boundaries, superpixels, etc.)



Question: What information can be shared when minimizing N energy functions for parametric min-cut, if pairwise costs, V_{uv} remain same across the functions?

Seed: $D_\lambda^i(x_u) = \infty$ iff $x_u \in S_i$ and $x_u = 0$. **Condition**: $S_i \cap S_j = \emptyset$, for all i, j

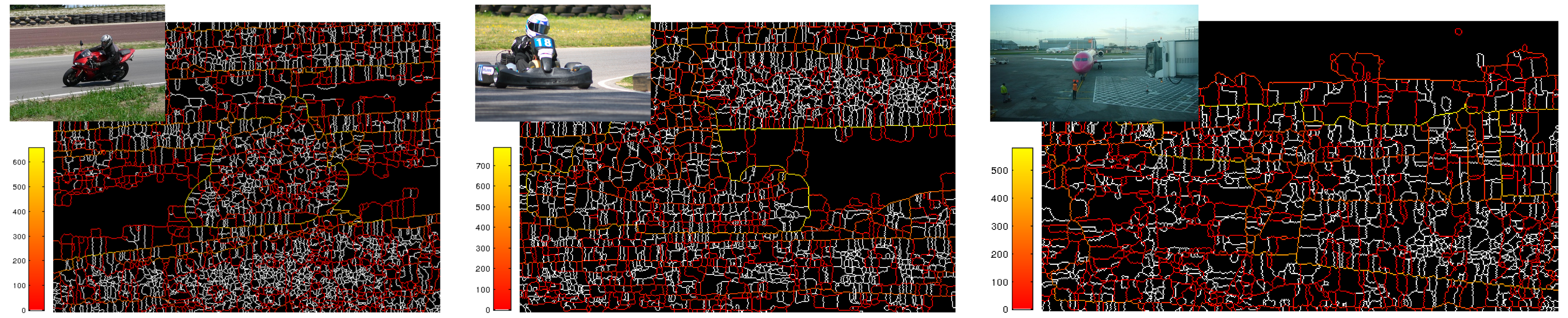


$$S_i \longrightarrow E_\lambda^i(\boldsymbol{X}) = \sum_{u \in \mathcal{V}} D_\lambda^i(x_u) + \sum_{(u,v) \in \mathcal{E}} V_{uv}(x_u, x_v)$$

$\updownarrow$ *Share information*

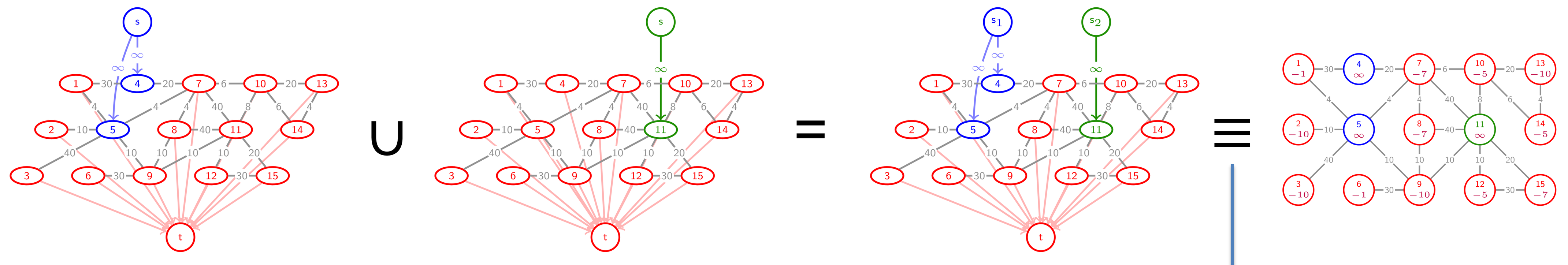
$$S_j \longrightarrow E_\lambda^j(\boldsymbol{X}) = \sum_{u \in \mathcal{V}} D_\lambda^j(x_u) + \sum_{(u,v) \in \mathcal{E}} V_{uv}(x_u, x_v)$$

Key Insight: Most of the edgelets between superpixels never get used in any parametric min-cut for any seed (about 43% edgelets).



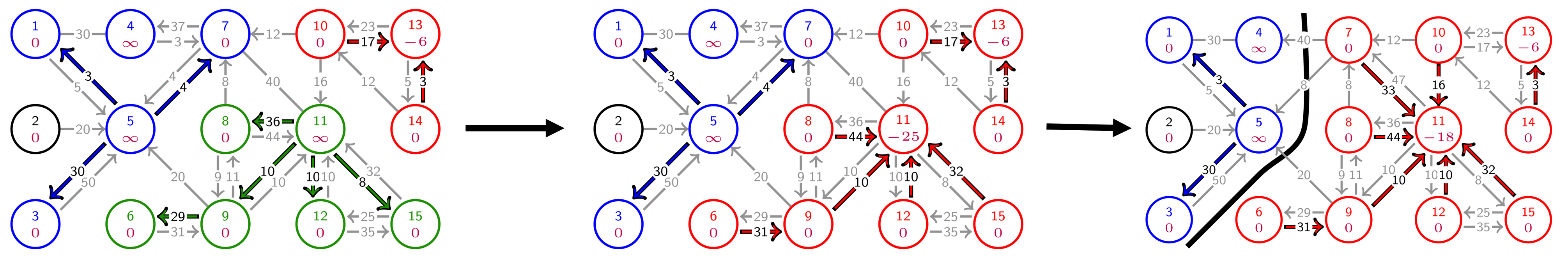
Novelty: Use a set of Boykov Kolmogorov [2] trees (one for each seed) to precompute information useful for all parametric min-cuts, in the case where pairwise costs do not change..

Step 1: Combine all seeds into one Precomputation Graph

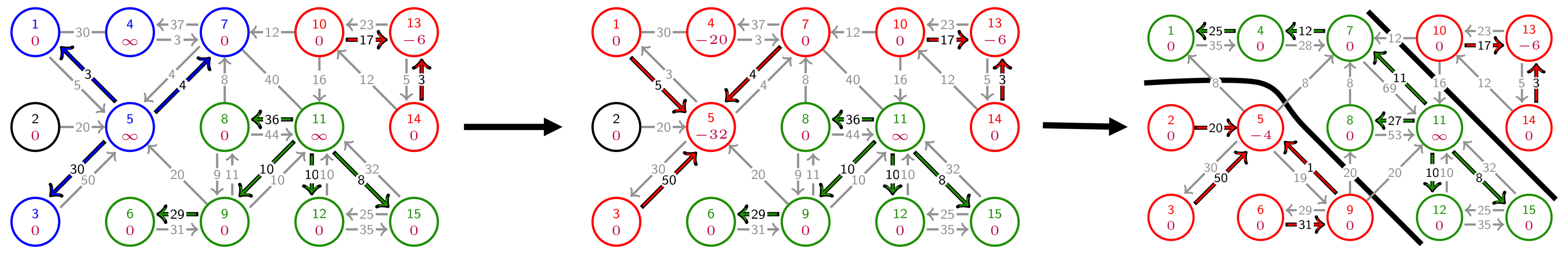


Step 2: $\mathcal{G}_p$ at end of Precomputation stage

Step 3: Reparameterize and cut by Max-flow (this retains the optimal solution)

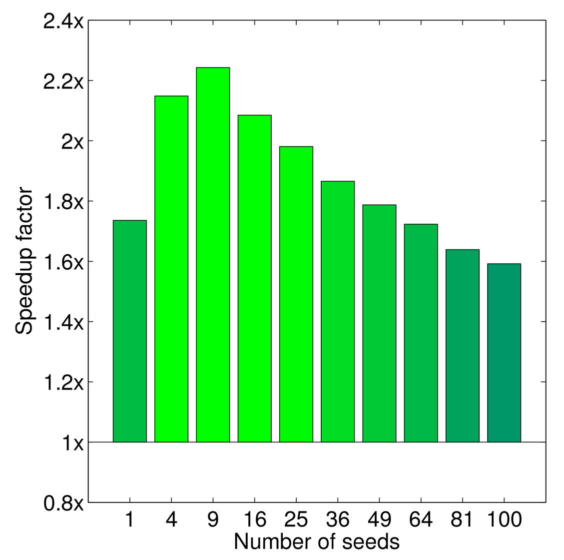


Repeat Step 3: Reparameterize and cut by Max-flow for all other seeds

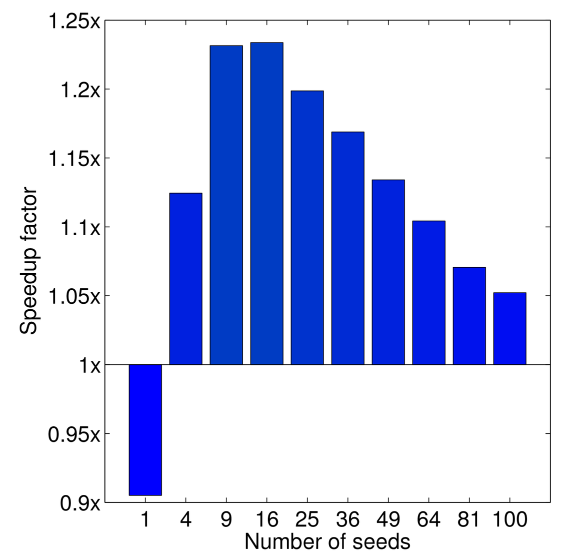


Results: Parametric min-cut timing comparison with increasing # of seeds.

Compared to Boykov Kolmogorov [2]



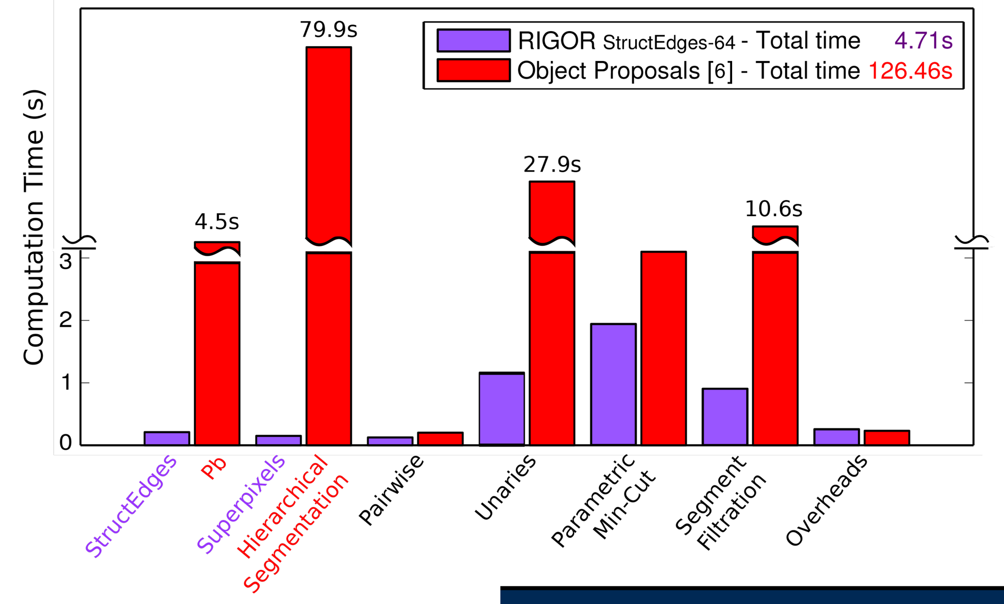
Compared to Kohli & Torr [4]



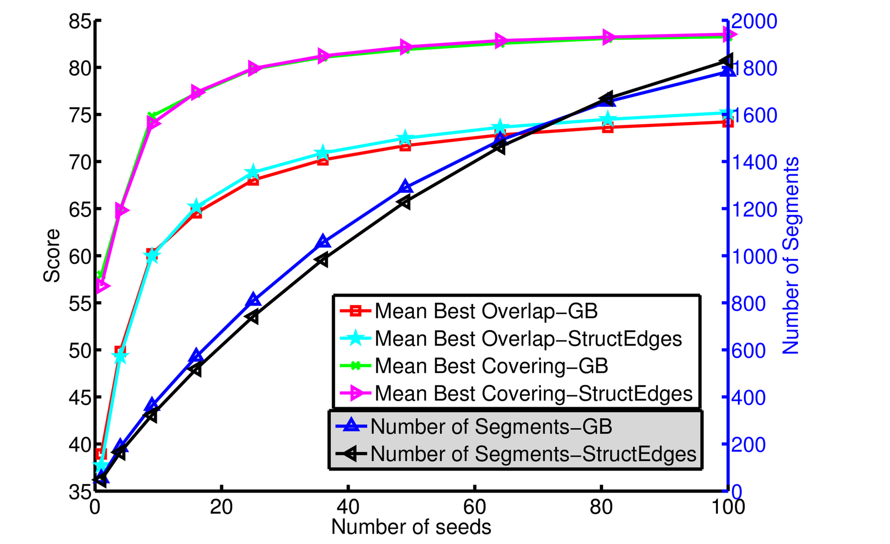
Parametric max-flow/min-cut timing comparison using different methods. StructEdges [3] was used in all tests.

RIGOR Time (ms)	9 Seeds	25 Seeds	64 Seeds
[2]	632.8	1,363.8	3,181.3
[4]	347.5	825.4	2,038.8
Ours	282.1	688.5	1,846.2

Pipeline timing comparison to Object Proposals [6]



Algorithm performance with changing # of seeds



Performance: Our algorithm performs slightly better and is an order of magnitude faster than CPMC [1]. It is ~25x times faster than Object Proposals [6] and ~100x faster than Shape Sharing [7].

	Method	Mean Best Overlap	Mean Best Covering	Run Time (s)	# Segments
	CPMC [1]	70.67	82.24	34.01	624.1
	Object Proposals [6]	71.48	80.98	126.46	1544.1
	Shape Sharing [7]	67.82	82.71	410.31	1115.4
	Selective Search (fast) [8]	73.48	77.71	3.80	3574.0
RIGOR	GB-25	68.04	79.83	4.62	808.7
RIGOR	StructEdges-25	68.85	79.89	**2.16**	741.9
RIGOR	GB-64	72.83	82.55	6.99	1490.3
RIGOR	StructEdges-64	73.64	82.84	4.71	1462.8
RIGOR	GB-100	74.22	83.25	9.26	1781.9
RIGOR	StructEdges-100	**75.19**	**83.52**	6.84	1828.7

References:

[1] J. Carreira and C. Sminchisescu. *CPMC: Automatic Object Segmentation Using Constrained Parametric Min-Cuts*. PAMI, 2012.
[2] Y. Boykov and V. Kolmogorov. *An experimental comparison of min-cut/maxflow algorithms for energy minimization in vision*. PAMI, 2004.
[3] P. Dollar and C. Zitnick. *Structured forests for fast edge detection*. In ICCV, 2013.
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[6] I. Endres and D. Hoiem. *Category independent object proposals*. In ECCV, 2010.
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