Multi-criteria Energy Minimization with Boundedness, Edge-density and Rarity, for Object Saliency in Natural Images

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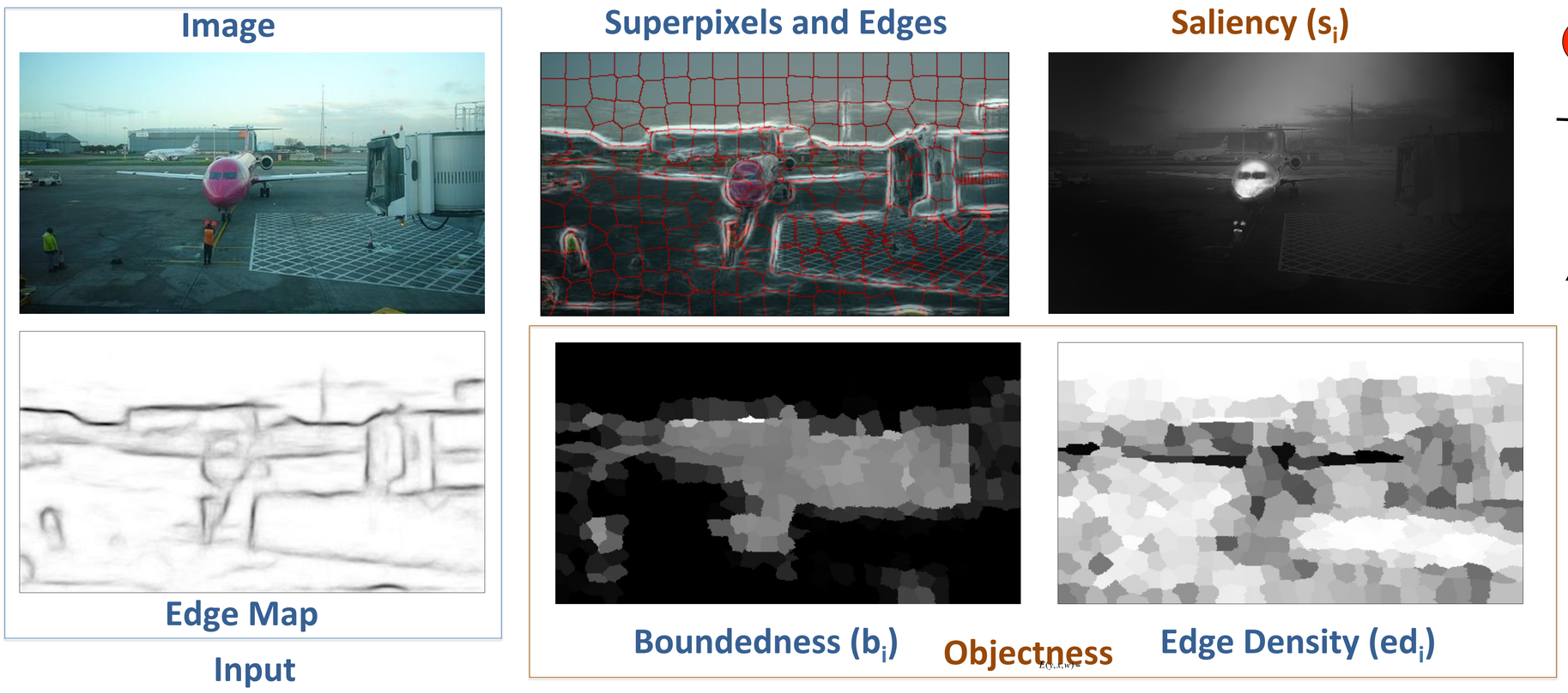
Abstract

- Motivated by saliency and category independent object segmentation methods, we predict a single object proposal which captures all the salient objects in an image, within O(number of superpixels)^3.
- The CRF parameters are learned using a margin-rescaled struct-SVM approach with (1- IoU) loss function.
- Fast but effective objectness criteria, viz. boundedness and edge-density. Submodular CRF is minimized using graph-cut. Results are shown on the challenging PASCAL VOC 2012 dataset.

Algorithm Overview



Energy Function over superpixels: $E(\mathbf{y},\mathbf{x},\mathbf{w}) = \sum_{i\in V}\phi_i^{(1)} + \lambda \sum_{(i,j)\in\mathcal{E}}\phi_{i,j}^{(2)}$

Salient Object Likelihood:

$\phi_i^{(1)}(y_i, x_i^{(1)}|w_1) = w_s\,((1-y_i)(1-s_i) + y_i s_i) + w_b\,((1-y_i)(1-b_i) + y_i b_i) + w_{ed}\,((1-y_i)\,ed_i + y_i\,(1-ed_i))$

Edge Cost:

$\phi_{i,j}^{(2)}(y_i, y_j, x_i^{(2)}, x_j^{(2)}) = |y_i - y_j|\exp(-k_c||c_i - c_j||)$

c_i denotes color of ith superpixel in lab space and k_c indicates the sensitivity of color similarity.

CRF parameter Learning:

- Convex in **w,** given $\mathcal{L}$
- Iteratively optimized, by finding $\mathbf{y_n}$ using graph-cut, and thus $\mathcal{L}$
- M is the number of training instances.
- $w = [w_1\ w_2] = [w_s\ w_b\ w_{ed}\ \lambda]^T$

$$\min_{\mathbf{w}} \frac{1}{2}\|\mathbf{w}\|^2 + \frac{1}{M}\sum_{n=1}^{M}\xi_n$$

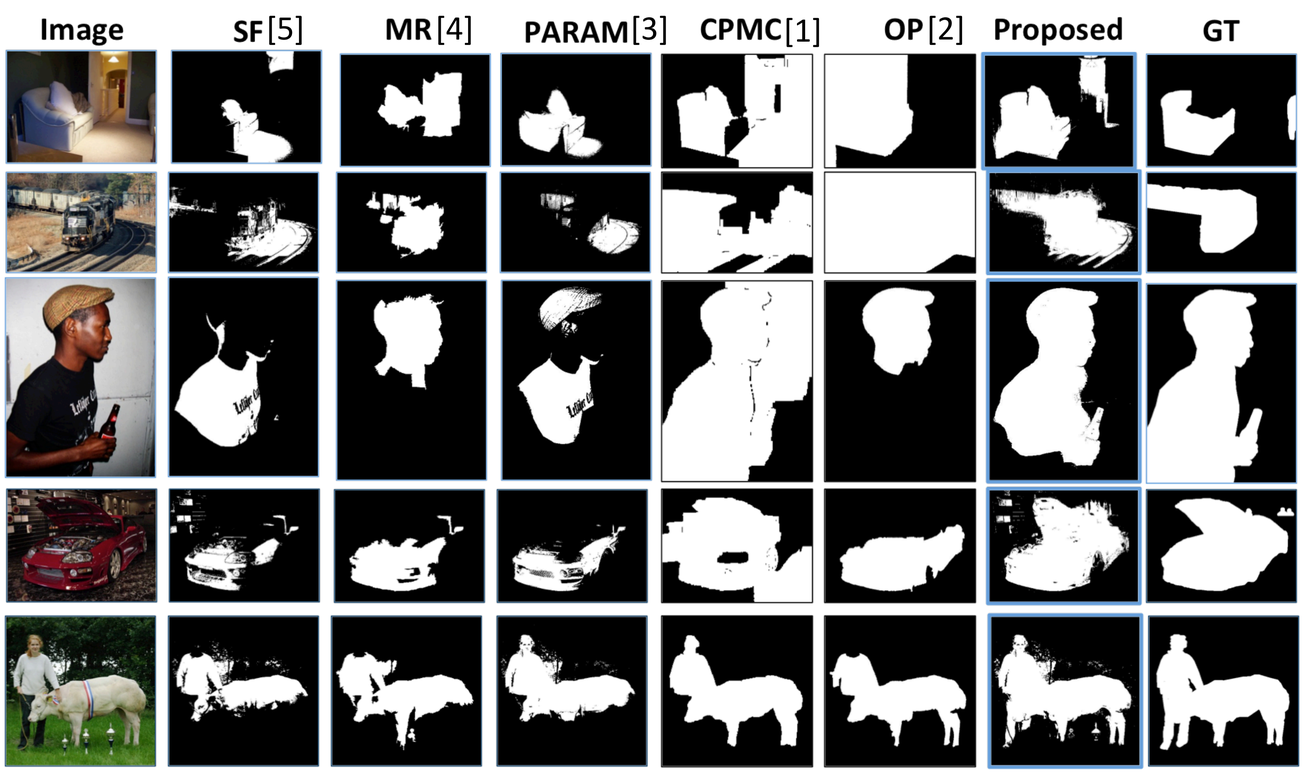
$$\text{subject to, } \mathbf{w}^{\mathbf{T}}\mathbf{v} = \mathbf{1}$$

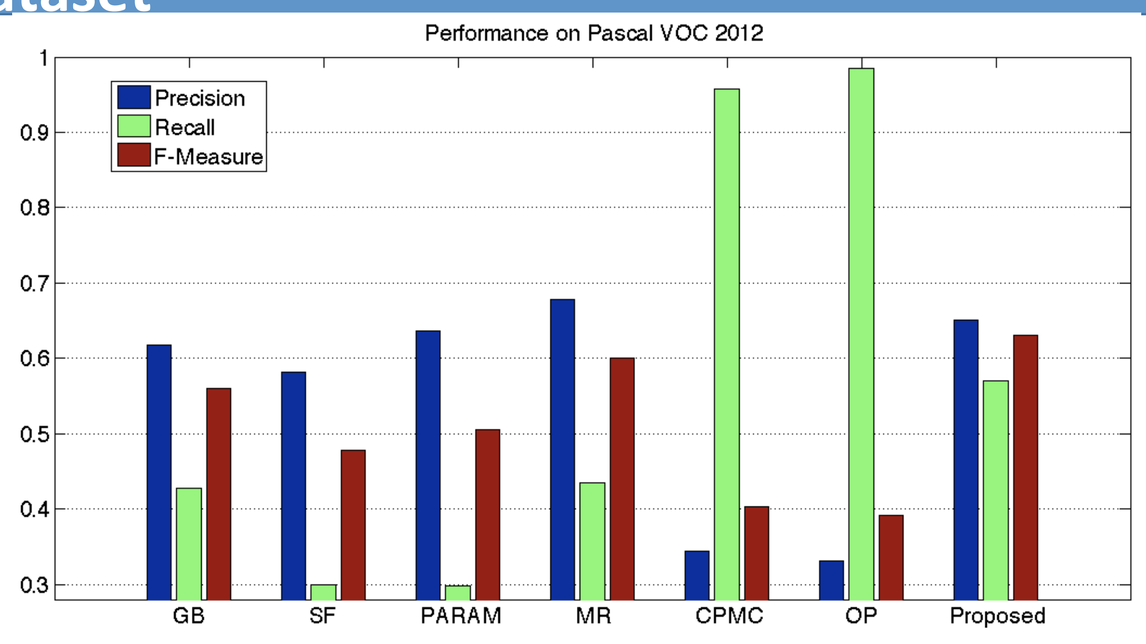
$$\mathbf{w}^T\phi_n - \mathbf{w}^T\hat{\phi}_n \le \mathcal{L}(\mathbf{y}_n,\hat{\mathbf{y}}_n) + \xi_n$$

$$\xi_n \ge 0, w_2 > 0$$

$\mathcal{L}$ = (1- IoU)

Results and Evaluations on PASCAL VOC 2012 Dataset





Method	CPMC [1] *	OP [2] *	Proposed
IoU Score	0.3319	0.3266	**0.4097**

* Considering top 10 proposal masks

Conclusion

- An efficient method based on saliency in conjunction with objectness cues to predict a category-independent object segmentation, using a CRF based formulation.
- Can be a preprocessing step for many high-level vision task.

References

1. Carreira and Sminchisescu, "Constrained parametric min-cuts for automatic object segmentation," CVPR, 2010.
2. Endres and Hoiem, "Category independent object proposals," ECCV, 2010.
3. Roy and Das, "Saliency detection in images using graph-based rarity, spatial compactness and background prior," VISAPP, 2014.
4. Yang, et. al., "Saliency detection via graph-based manifold ranking," CVPR, 2013.
5. Perazzi et. al., Saliency filters: Contrast based filtering for salient region detection. CVPR. 2012.