

A NEW MULTI-CRITERIA FUSION MODEL FOR COLOR TEXTURED IMAGE SEGMENTATION

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Introduction: Image segmentation

- Image segmentation aims to divide an image into several disjoint regions with uniform and homogeneous attributes



Problem:

- Fusion of image segmentations based on the optimization of a single criterion may bias the performance of an image segmentation model

Key Idea 1: Combining multiple, quickly estimated segmentation maps of the same image to obtain a final refined segmentation



Key Idea 2: Combining two conflicting and complementary segmentation criteria

Contour-based F-measure criterion

- A combination of two complementary measures; precision (P) and recall (R)

$$F_\alpha = \frac{PR}{\alpha R + (1 - \alpha)P} \quad (1)$$

with

α : Relative cost between P and R

- $F_\alpha = 1$ \Rightarrow Similar boundaries exists between the two segmentations to be compared
- $F_\alpha = 0$ \Rightarrow Maximum difference of boundaries between the two segmentations

Region-based Vol criterion

- Based on the entropy
- Measures the amount of information that is lost or gained in changing from one clustering to another

$$\text{Vol}(S^a, S^b) = H(S^a) + H(S^b) - 2I(S^a, S^b) \quad (2)$$

with

$$H(S^a) = - \sum_{i=1}^{R^a} P(i) \log P(i) = - \sum_{i=1}^{R^a} \left(\frac{n_i^a}{n}\right) \log \left(\frac{n_i^a}{n}\right) \quad (3)$$

$$H(S^b) = - \sum_{j=1}^{R^b} P(j) \log P(j) = - \sum_{j=1}^{R^b} \left(\frac{n_j^b}{n}\right) \log \left(\frac{n_j^b}{n}\right) \quad (4)$$

and

$$I(S^a, S^b) = \sum_{i=1}^{R^a} \sum_{j=1}^{R^b} P(i,j) \log \left(\frac{P(i,j)}{P(i)P(j)} \right) \quad (5)$$

where

$S^a = \{C_1^a, C_2^a, \dots, C_{R^a}^a\}$: Segmentation

$S^b = \{C_1^b, C_2^b, \dots, C_{R^b}^b\}$: Segmentation

n : Number of pixels within the image

n_i^a : Number of pixels in the i^{th} cluster i of S^a

$P(i) = n_i^a/n$: Probability that a pixel belongs to cluster S^a

$P(i,j) = n_{ij}/n$: Probability when a pixel \in to C_i^a and to C_j^b

- $Vol = 0$ \Rightarrow Maximum similarity between the two segmentations
- $Vol = 1$ \Rightarrow Maximum difference between the two segmentations

Multi-criteria fusion model based on the entropy-weighted formula approach (EFA-BMFM)

$$\hat{S}_{\text{MO}} = \arg \min_{S \in \mathcal{S}_n} \overline{\text{MO}}(S, \{S_k\}_{k \leq L}) \quad (6)$$

with

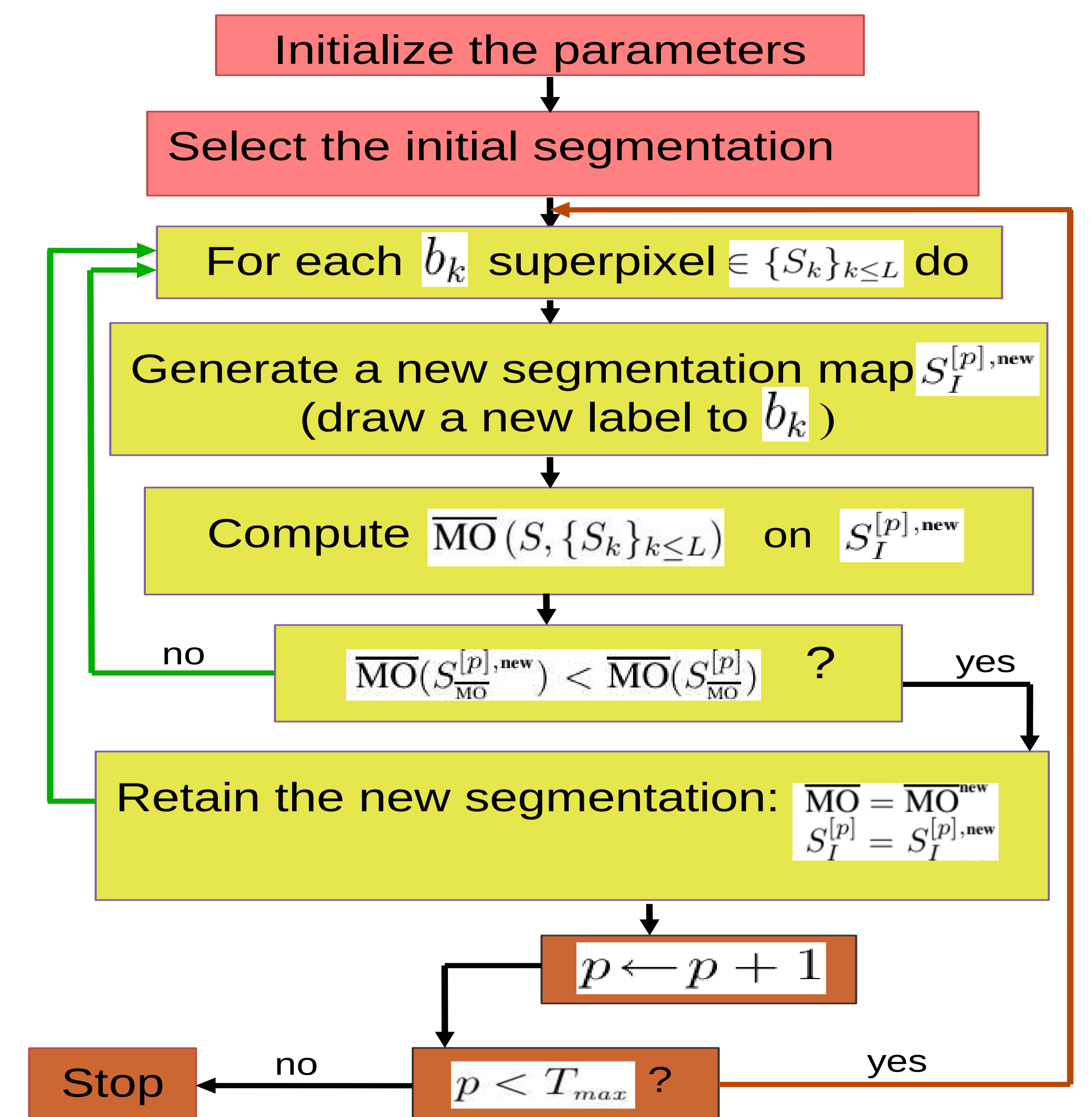
$$\overline{\text{MO}}(\cdot) = w_{\text{vol}} \overline{\text{Vol}}(S, \{S_k\}_{k \leq L}) + \frac{w_{\text{f}}}{\overline{F}_\alpha(S, \{S_k\}_{k \leq L})} \quad (7)$$

where

$$\overline{C}(S, \{S_k\}_{k \leq L}) = \frac{1}{L} \sum_{k=1}^L C(S, S_k) \quad (8)$$

Optimization

- Based on the ensemble of regions provided by each individual segmentations to be fused
- Algorithm: Iterative Conditional Modes (ICM) [1]

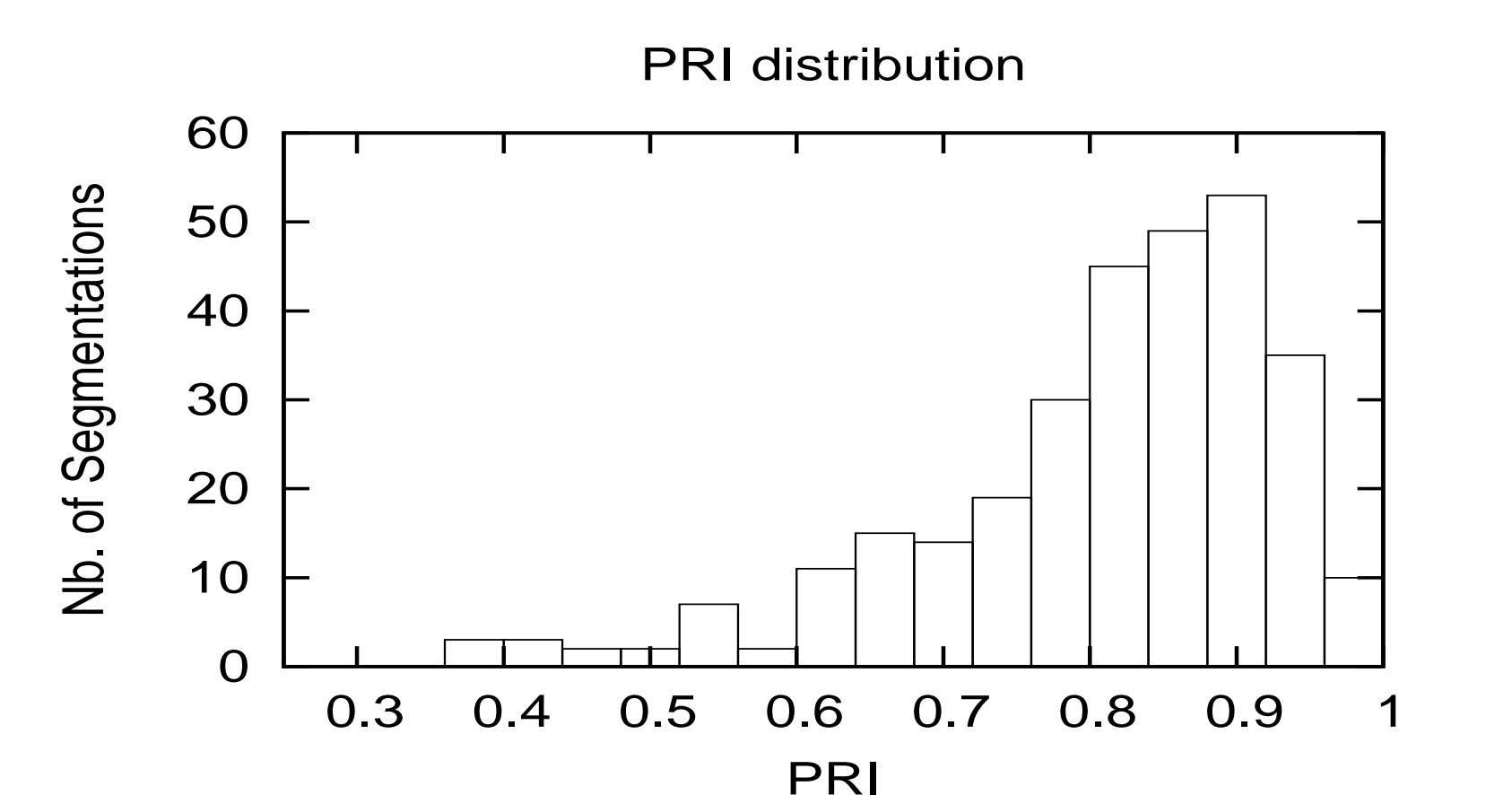
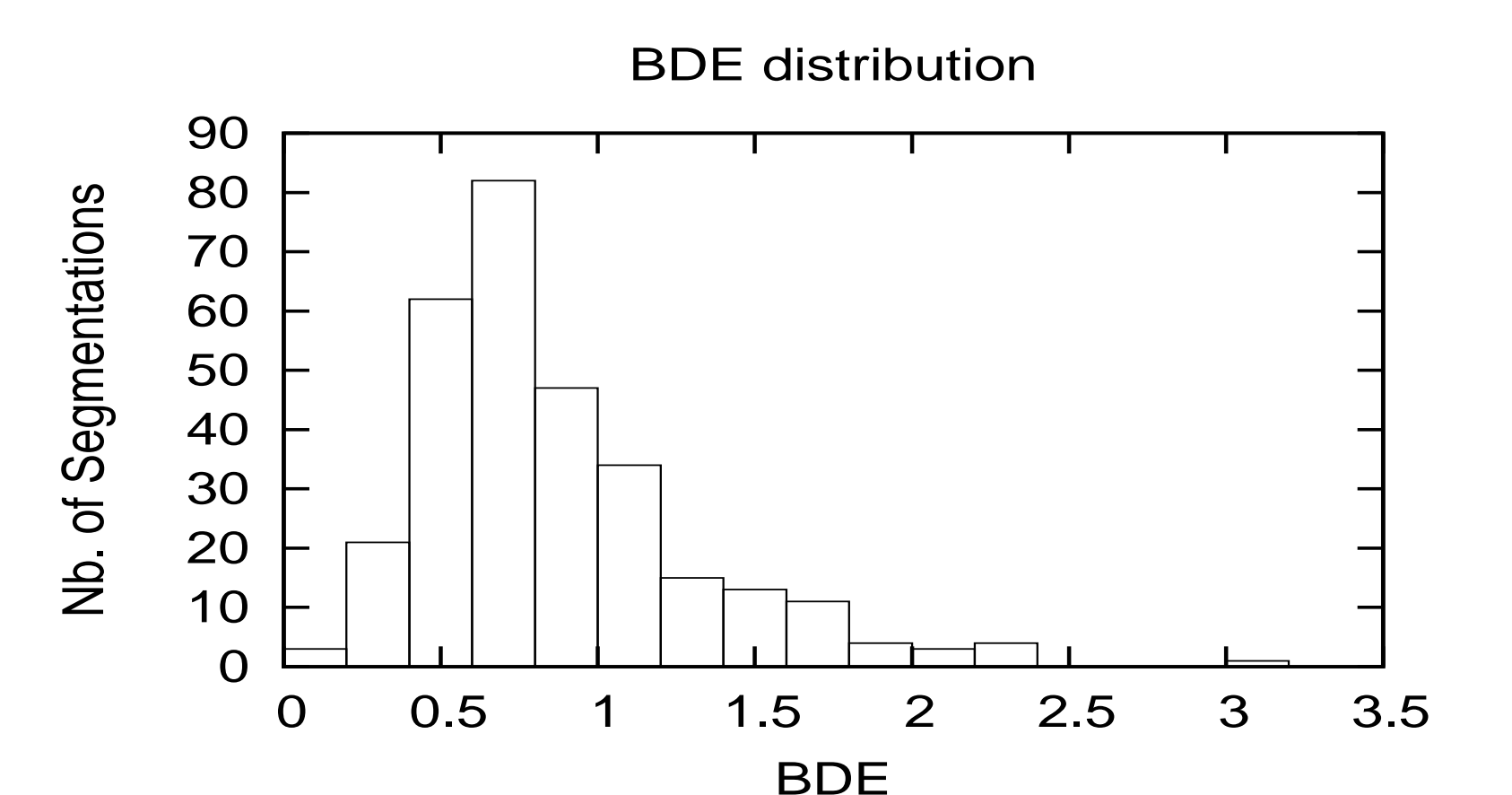


Results

Performances on the BSDS300

Algorithms	Vol ↓	BDE ↓	GCE ↓	PRI ↑
Humans	1.10	4.99	0.08	0.87
EFA-BMFM	1.87	8.16	0.19	0.80
VOIBFM [2]	1.88	8.49	0.21	0.81
FCR [3]	2.30	8.99	0.21	0.79

Distribution of the BDE and PRI measures over the 300 segmented images of the BSDS300



Example of segmentations result



References

- [1] J. Besag. On the statistical analysis of dirty pictures. *Journal of the Royal Statistical Society*, B-48:259–302, 1986.
- [2] M. Mignotte. A label field fusion model with a variation of information estimator for image segmentation. *Inf. Fusion*, 20(0):7–20, 2014.
- [3] M. Mignotte. Segmentation by fusion of histogram-based K-means clusters in different color spaces. *IEEE Trans. Image Process.*, 17:780–787, 2008.