

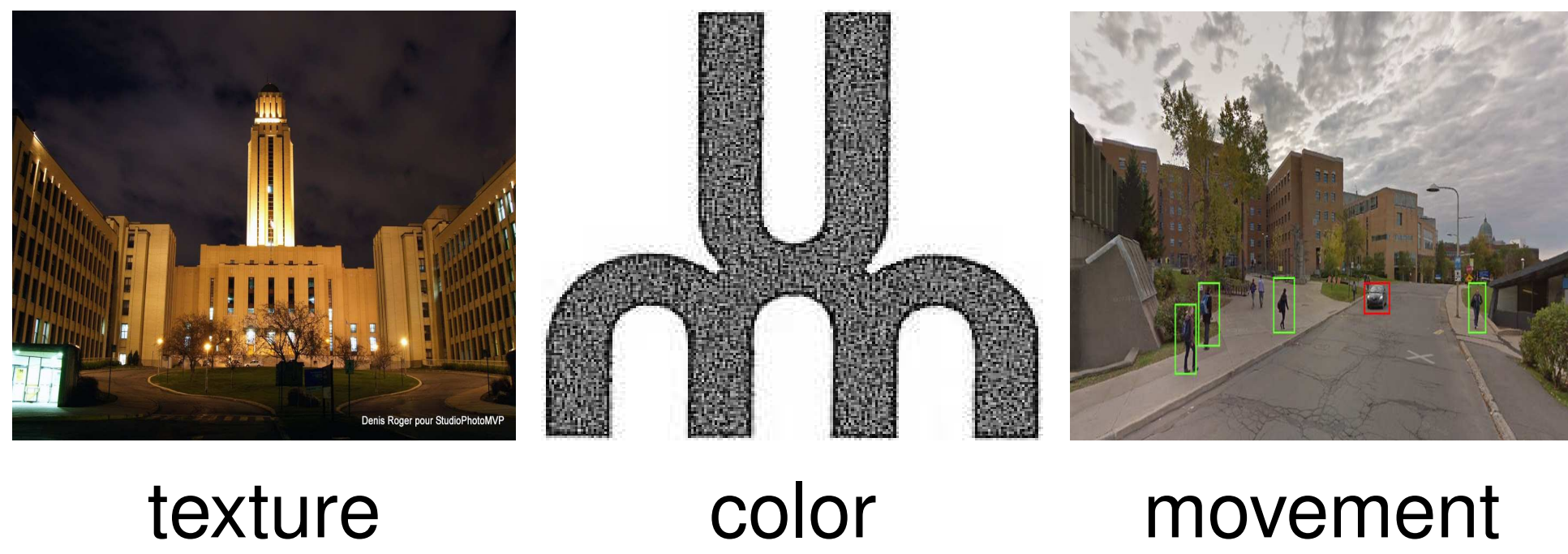
GCE-BASED MODEL FOR THE FUSION OF MULTIPLES COLOR IMAGE SEGMENTATIONS

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Introduction: Image segmentation

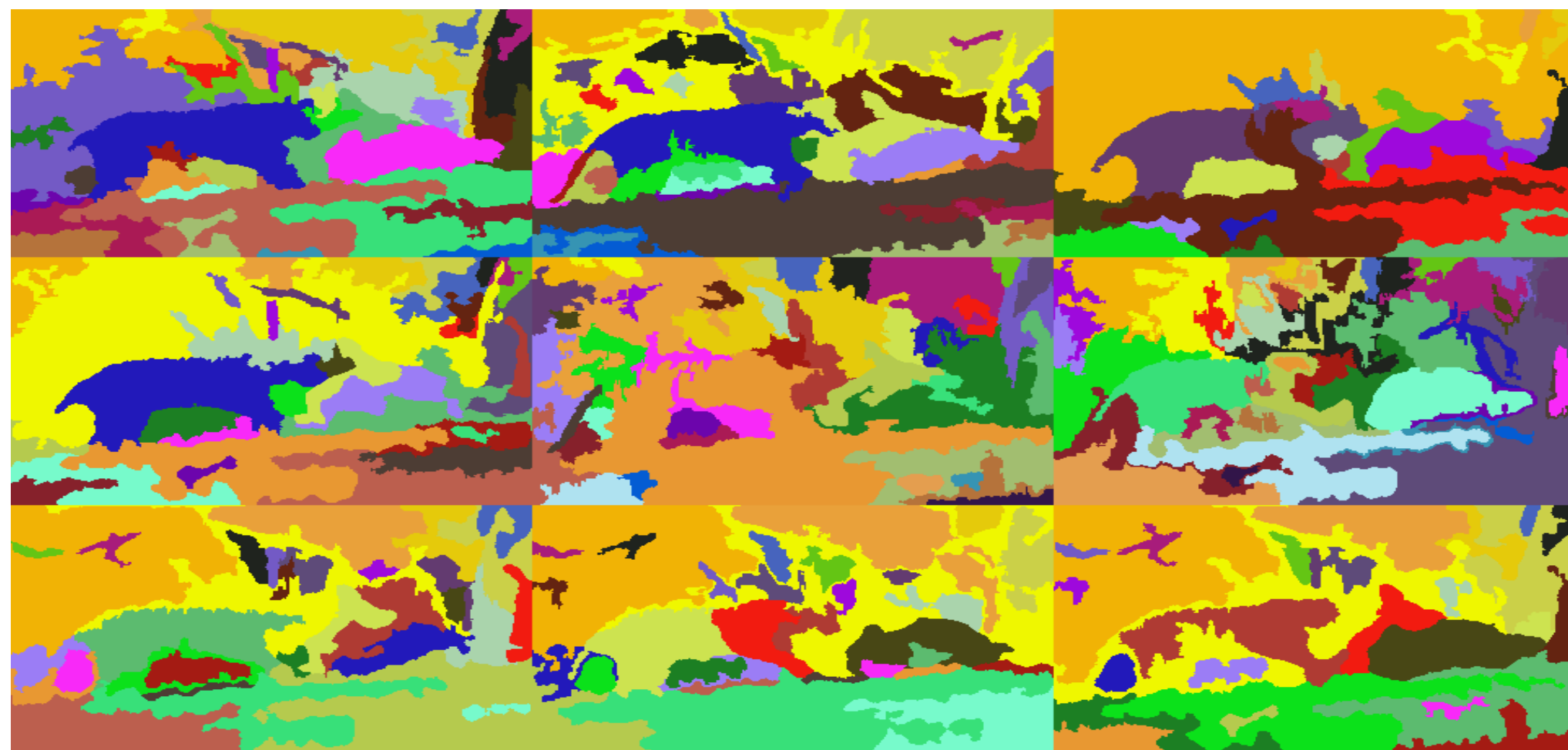
- Aims to represent the image content into different regions of coherent properties with homogeneous characteristics:



Problem: Ill-posed problem

- Selected criterion for grouping pixels depends on the goal of the segmentation
- A unique algorithm cannot perform adequately for all applications

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



Segmentation criterion: Global Consistency Error (GCE)

- Measures the extent to which one segmentation map can be viewed as a refinement of another segmentation

$$GCE^*(S^t, S^g) = \frac{1}{2n} \left\{ \sum_{i=1}^n LRE(S^t, S^g, p_i) + \sum_{i=1}^n LRE(S^g, S^t, p_i) \right\} \quad (1)$$

with

$$LRE(S^t, S^g, p_i) = \frac{|C_{<p_i>}^t \setminus C_{<p_i>}^g|}{|C_{<p_i>}^t|} \quad (2)$$

where

$S^t = \{C_1^t, C_2^t, \dots, C_R^t\}$: Segmentation

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

R^t : Number of region in S^t

R^g : Number of region in S^g

p_i : Pixel

$C_{<p_i>}^t$: Segments in S^t including p_i

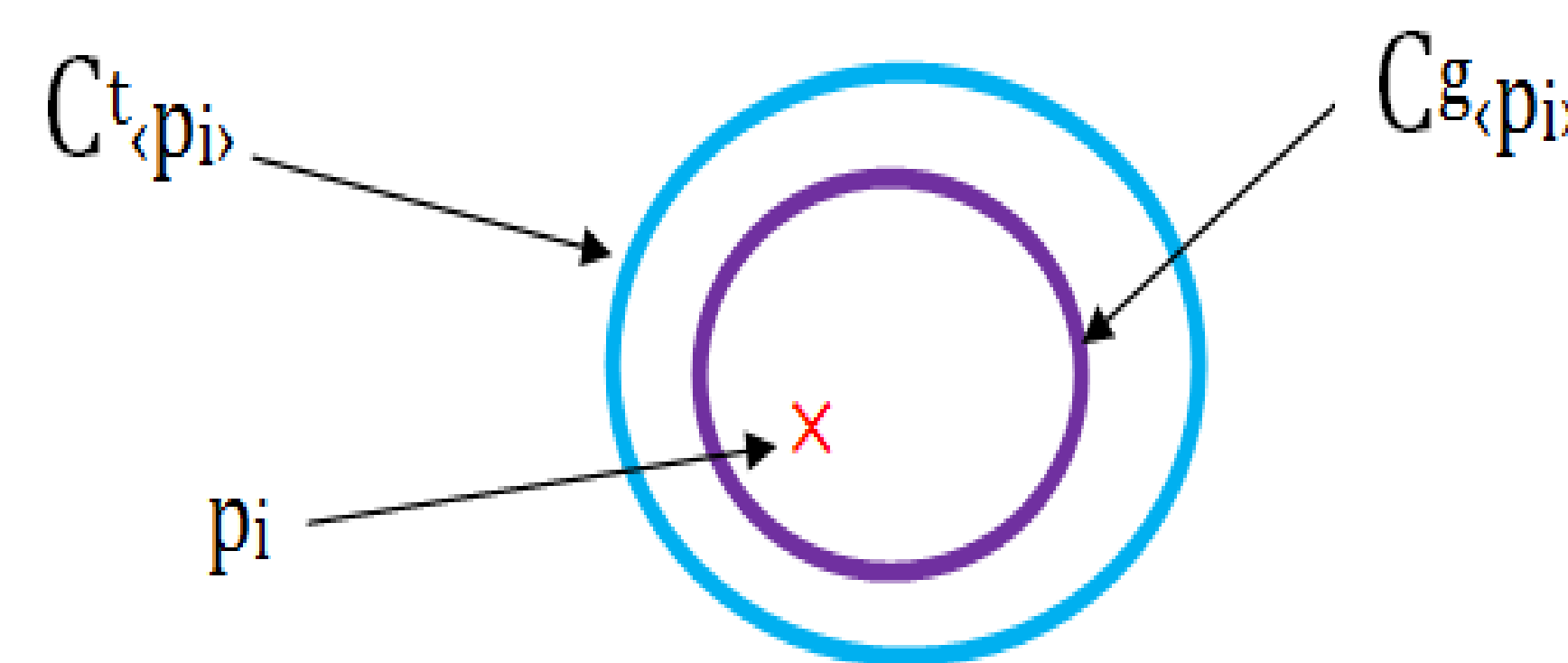
$C_{<p_i>}^g$: Segments in S^g including p_i

\setminus : Set differencing operator

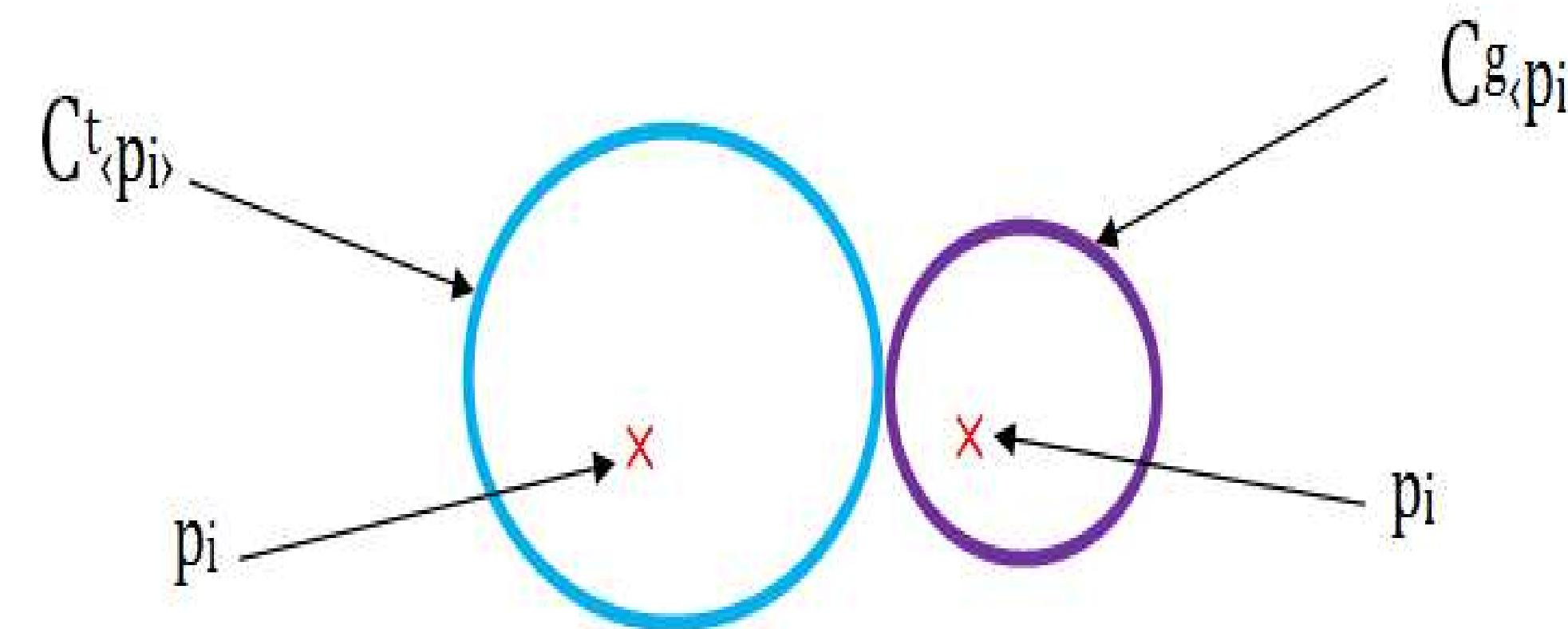
n : Number of pixel within the image

$|C|$: Cardinality of the set of pixels C

- **GCE= 0** \Rightarrow Perfect match between the two segmentations to be compared



- **GCE= 1** \Rightarrow Maximum difference between the two segmentations



GCE-Based Fusion Model

$$\hat{S}_{GCE_\beta}^* = \arg \min_{S \in \mathcal{S}_n} \left\{ \overline{GCE}^*(S, \{S_k\}_{k \leq L}) + \beta E_{Reg}(S) \right\} \quad (3)$$

with

$$\overline{GCE}^*(S^t, \{S_k^g\}_{k \leq L}) = \frac{1}{L} \sum_{k=1}^L GCE^*(S^t, S_k^g) \quad (4)$$

and

$$E_{Reg}(S = \{C_k\}_{k \leq R}) = \left| - \sum_{k=1}^R \frac{|C_k|}{n} \log \frac{|C_k|}{n} - \bar{\mathcal{R}} \right| \quad (5)$$

where

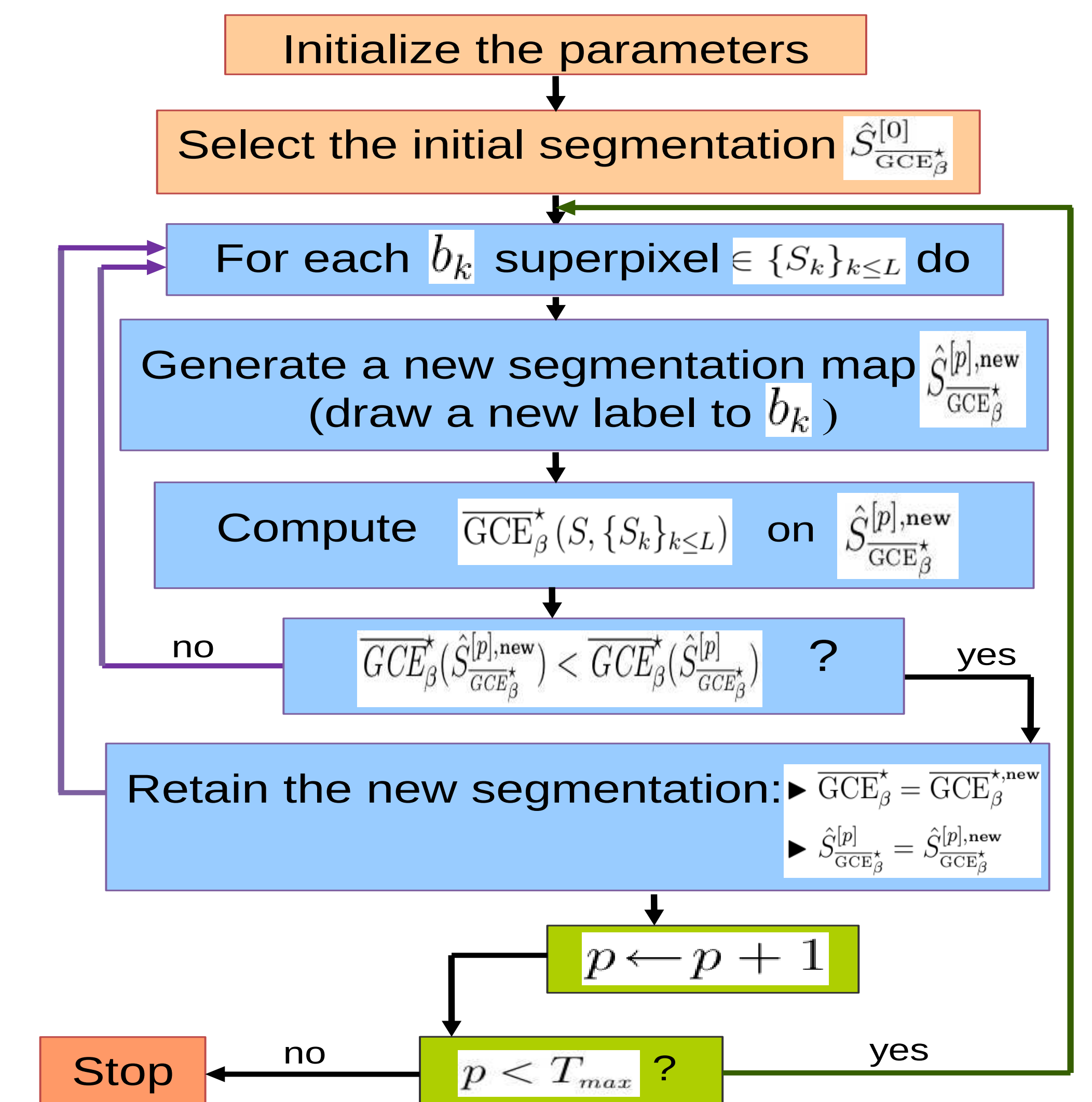
β : Regularization parameter

$|C_k|$: Number of pixel in the k -th region C_k of the segmentation map S

$\bar{\mathcal{R}}$: Internal parameter defines the mean entropy of the a priori defined acceptable segmentation solutions

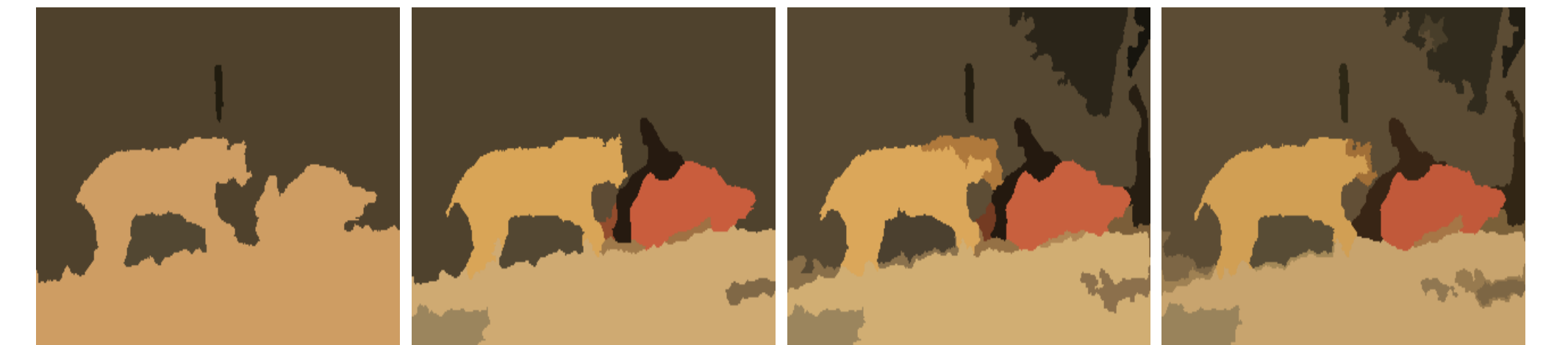
Optimization

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



Results

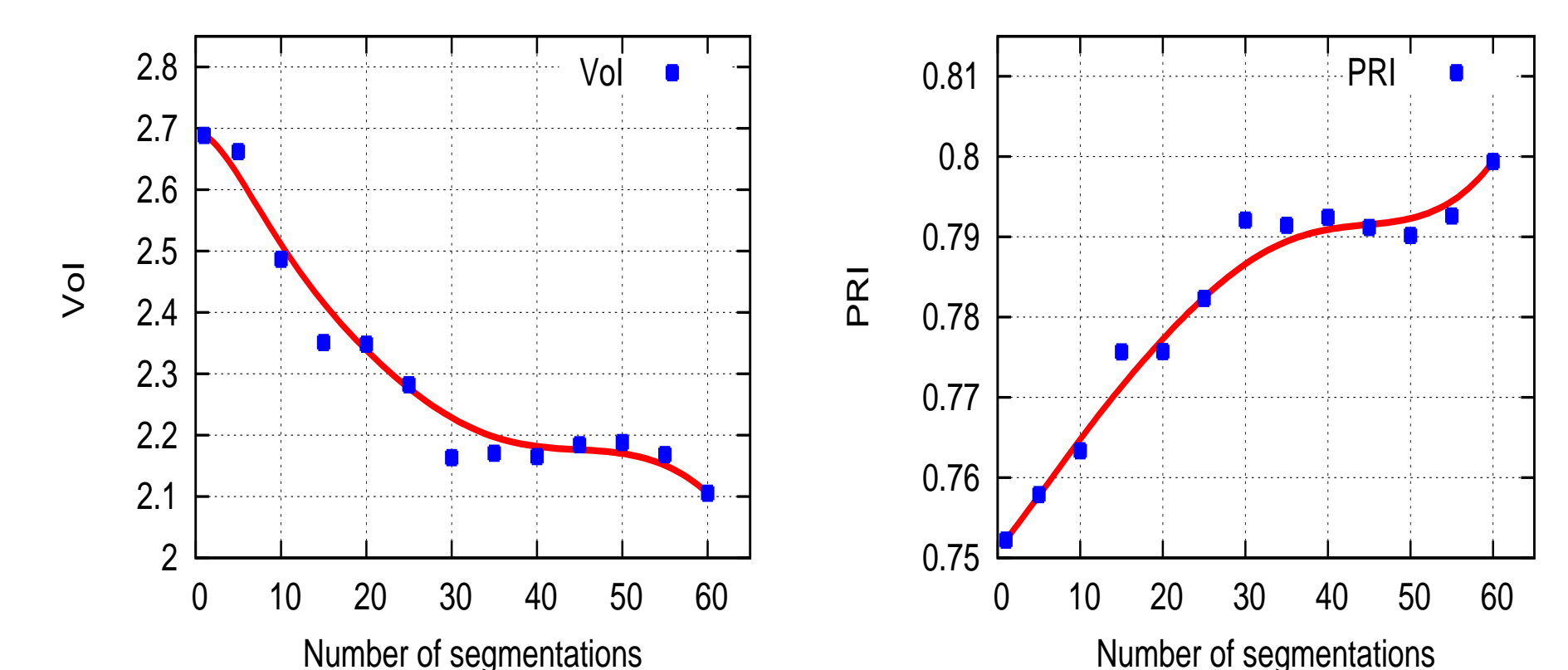
Example of segmentation solutions generated for different values of $\bar{\mathcal{R}}$



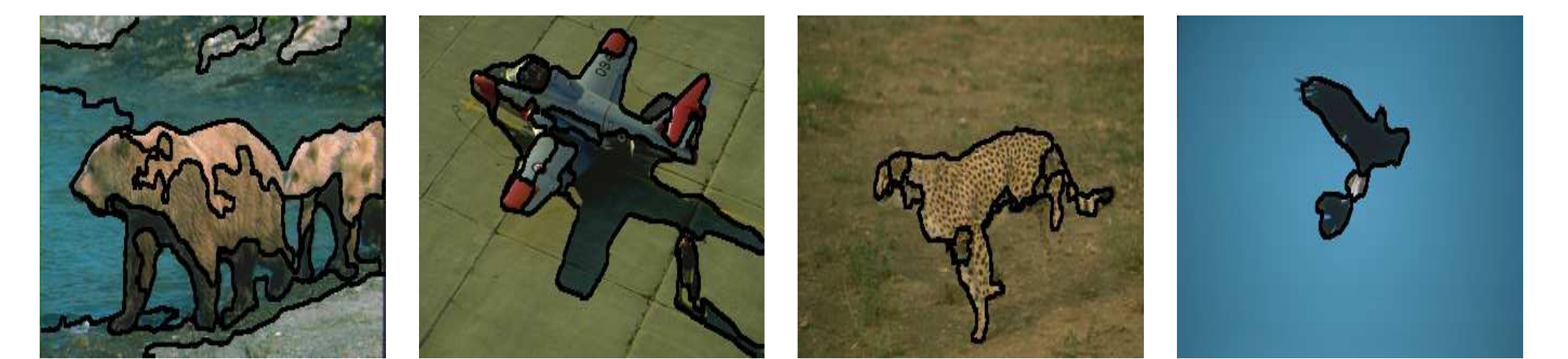
Performances on BSDS300

Algorithms	Vol ↓	BDE ↓	GCE ↓	PRI ↑
Humans	1.10	4.99	0.08	0.87
GCEBFM	2.10	8.73	0.19	0.80
PRIF [2]	1.97	8.45	0.21	0.80
FCR [3]	2.30	8.99	0.21	0.79

Progression of the PRI and the Vol according to the number of segmentations (L)



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 Bayesian model and its penalized maximum Rand estimator for image segmentation. *IEEE Trans. Image Process.*, 19(6):1610–1624, 2010.
- [3] M. Mignotte. Segmentation by fusion of histogram-based K-means clusters in different color spaces. *IEEE Trans. Image Process.*, 17:780–787, 2008.