(RF)^2 - Random Forest Random Field

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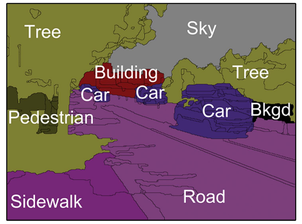
A MOTIVATING EXAMPLE PROBLEM

Given a set of image regions,

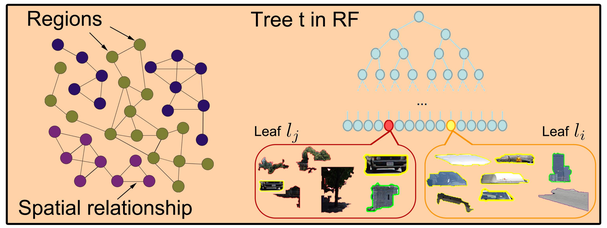


Label each region as one of multiple object classes

Typically formulated using CRF to account for spatial and semantic context

OVERVIEW

Hierarchy of regions



MCMC based multicoloring of CRF

Acceptance rate of Metropolis-Hastings jumps in MCMC is computed using Random Forest (RF)

CONTRIBUTIONS

Use **RANDOM FOREST** for a **NON-PARAMETRIC, DATA DRIVEN** MCMC of CRF

CRF

Find optimal labeling $\boldsymbol{Y}^* = \arg\max_{\boldsymbol{Y}} p(\boldsymbol{Y}|G)$

$$p(Y|G) = \prod_{i\in V} \underbrace{p(y_i|x_i)}_{p_i} \prod_{(i,j)\in E} \underbrace{p(y_i, y_j|x_i, x_j, e_{ij})}_{p_{ij}}$$

(x_i, y_i) = (region descriptor, class label)

G = Input hierarchy of regions

INFERENCE: SW-CUT

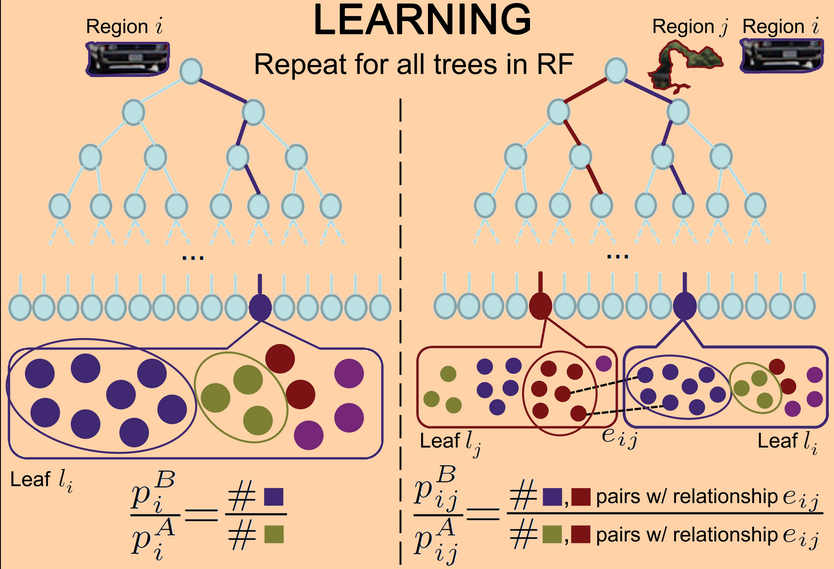
$$\alpha(A \to B) = min\left(1, \frac{q(B\to A)}{q(A\to B)} \frac{p(Y=B|G)}{p(Y=A|G)}\right)$$

acceptance rate — ratio of proposals — ratio of posteriors

$$\frac{q(B\to A)}{q(A\to B)} = \frac{\prod_{(i,j)\in Cut_B}(1-p_{ij}^B)}{\prod_{(i,j)\in Cut_A}(1-p_{ij}^A)}, \quad \frac{p(Y=B|G)}{p(Y=A|G)} = \prod_{i\in CC}\frac{p_i^B}{p_i^A} \cdot \prod_{j\in\mathcal{N}(i)}\frac{p_{ij}^B}{p_{ij}^A}$$

LEARNING

Repeat for all trees in RF



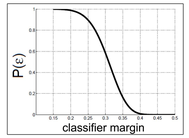
THEORETICAL ANALYSIS

Probability of error: $P(\epsilon) = P\left(\frac{p(\boldsymbol{Y}=B|G)}{p(\boldsymbol{Y}=A|G)} \geq 1\right) = P\left(\prod_{i\in CC}\frac{p_i^B}{p_i^A} \cdot \prod_{j\in\mathcal{N}(i)}\frac{p_{ij}^B}{p_{ij}^A} \geq 1\right)$

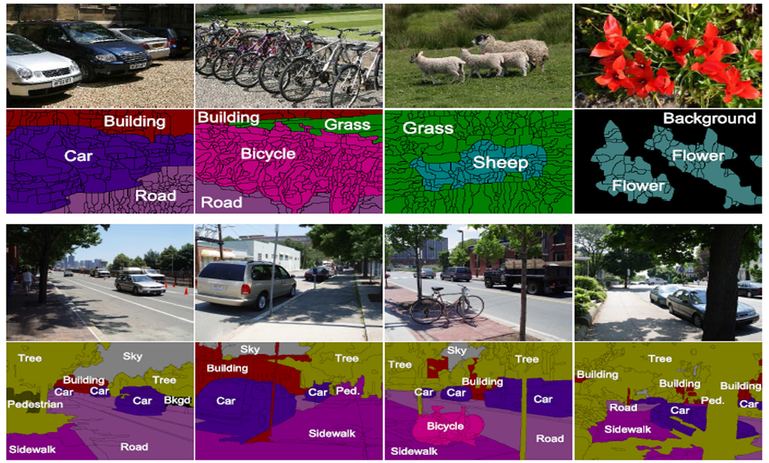
Main result: $P(\epsilon) = \lambda K_1(\lambda)$

K_1: modified Bessel function of the second kind

$\lambda \propto$ (number of trees in RF,
number of instances in a leaf node,
classifier margin)



RESULTS



Our object recognition and segmentation results on example images from the MSRC dataset (top two rows) and the Street-Scene dataset (bottom two rows).

Method	Aeroplane	Bicycle	Bird	Boat	Body	Book	Building	Car	Cat	Chair	Cow	Dog	Face	Flower	Grass	Road	Sheep	Sign	Sky	Tree	Water
[10]	88	91	34	49	54	93	30	82	56	74	68	54	77	90	71	31	64	82	84	69	58
[22]	82	72	24	18	66	93	49	74	75	51	97	35	87	74	88	78	97	36	78	79	54
[23]	83	79	30	27	67	80	69	70	68	45	78	52	84	47	96	78	80	61	95	87	67
[20]	**100**	98	11	63	55	78	73	**88**	11	**80**	74	43	72	72	96	76	90	92	50	76	61
[3]	60	75	19	7	62	92	62	63	54	15	58	19	74	63	97	**86**	50	35	83	86	53
Ours	**100**	**99**	**42**	**69**	**68**	**95**	**74**	**88**	**77**	**80**	**99**	**61**	**91**	**93**	**99**	78	**99**	**93**	**96**	**90**	**68**

The average pixel classification accuracy on the MSRC dataset