Object-Graphs for Context-Aware Category Discovery

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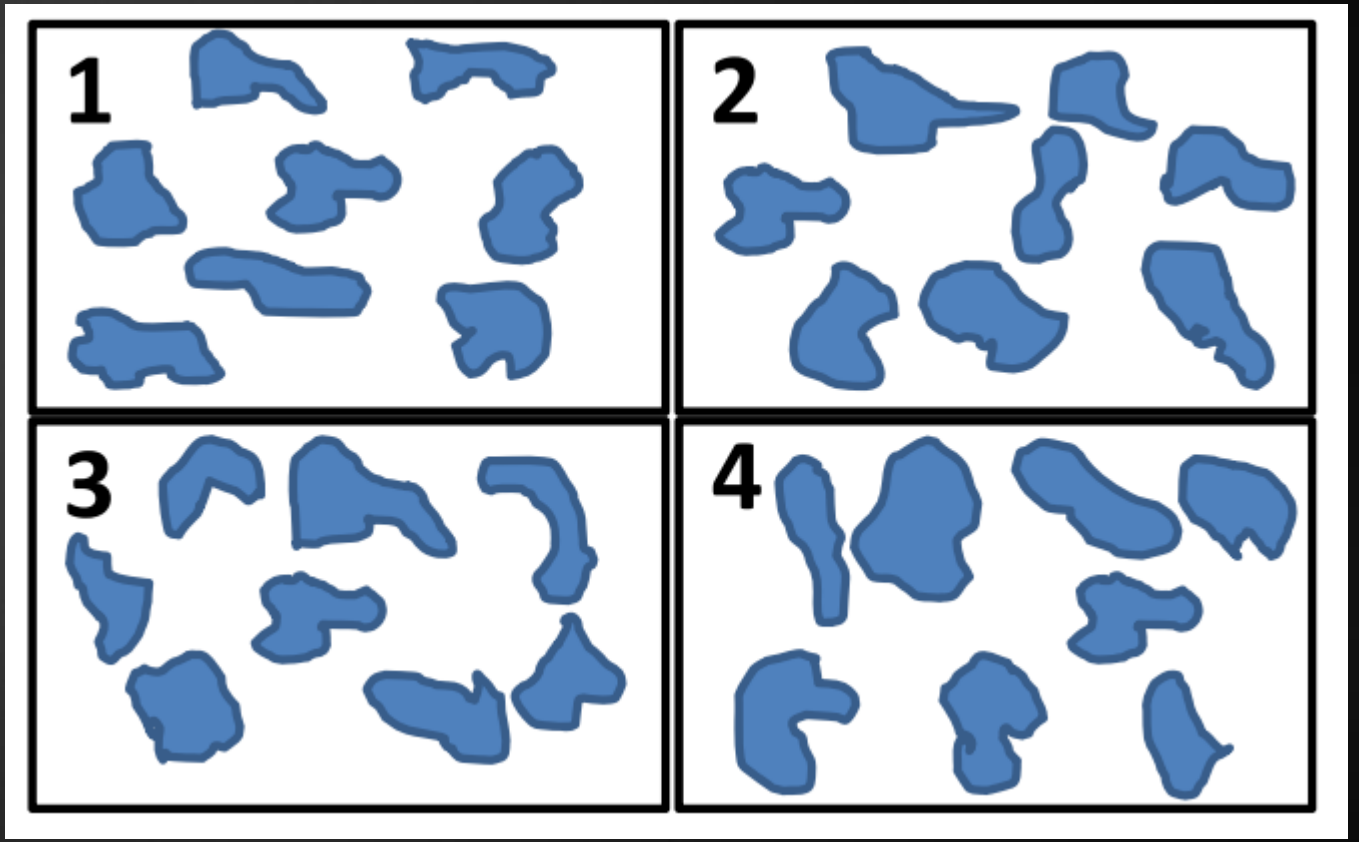
Problem

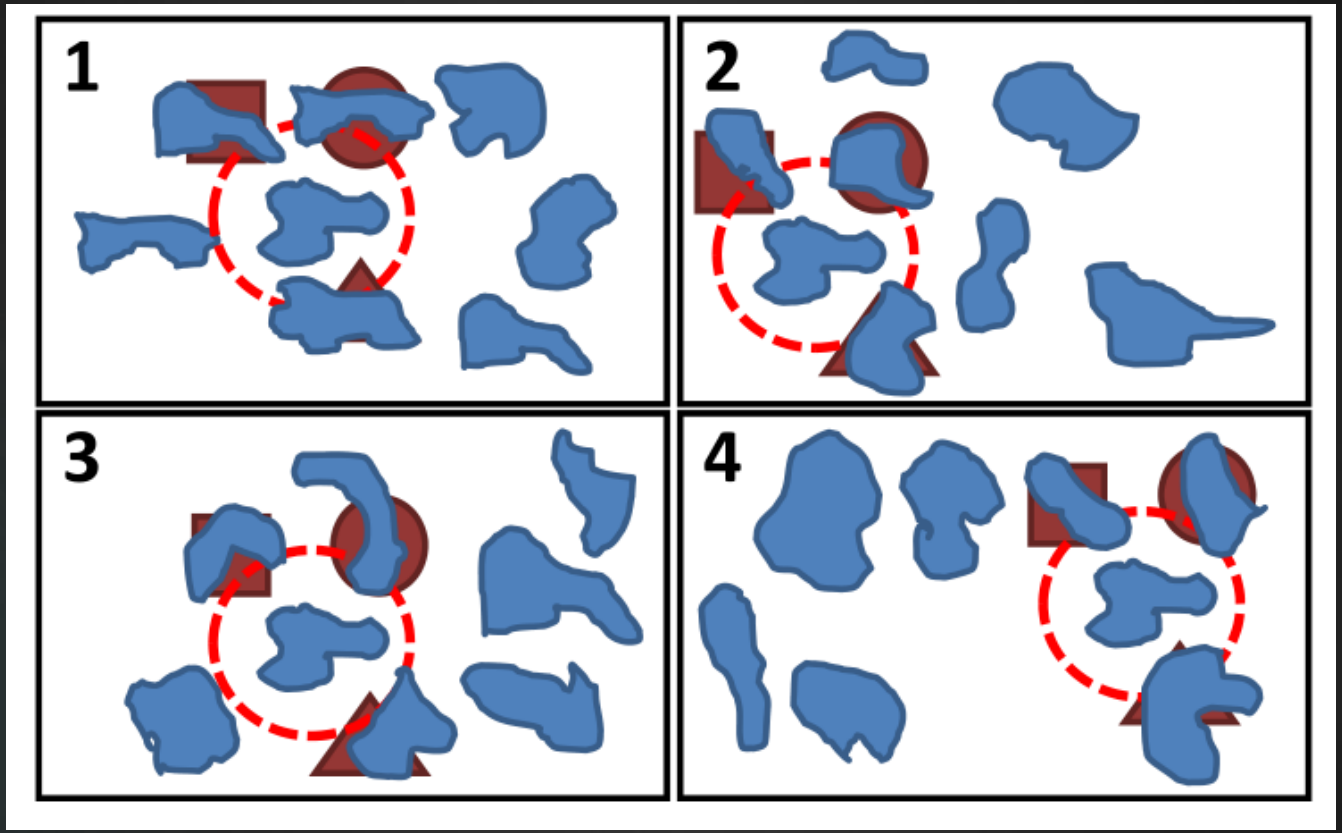
- Find structure in large dataset
- Training data not always available

Background

- Topic models
  - pLSA, LDA
- Appearance based grouping problem

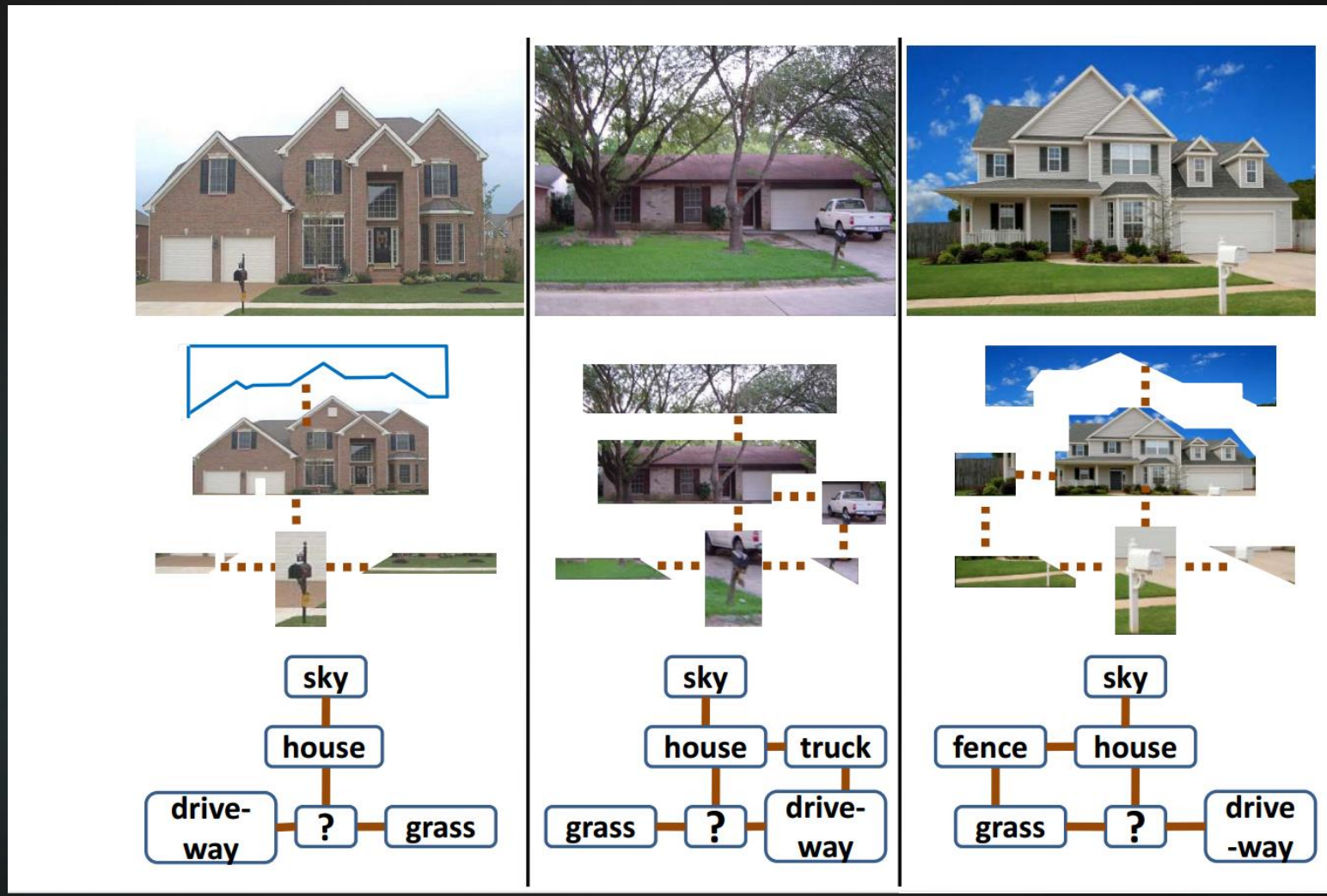


Idea



- Does seeing known objects help discover new categories?

Context Aware Discovery

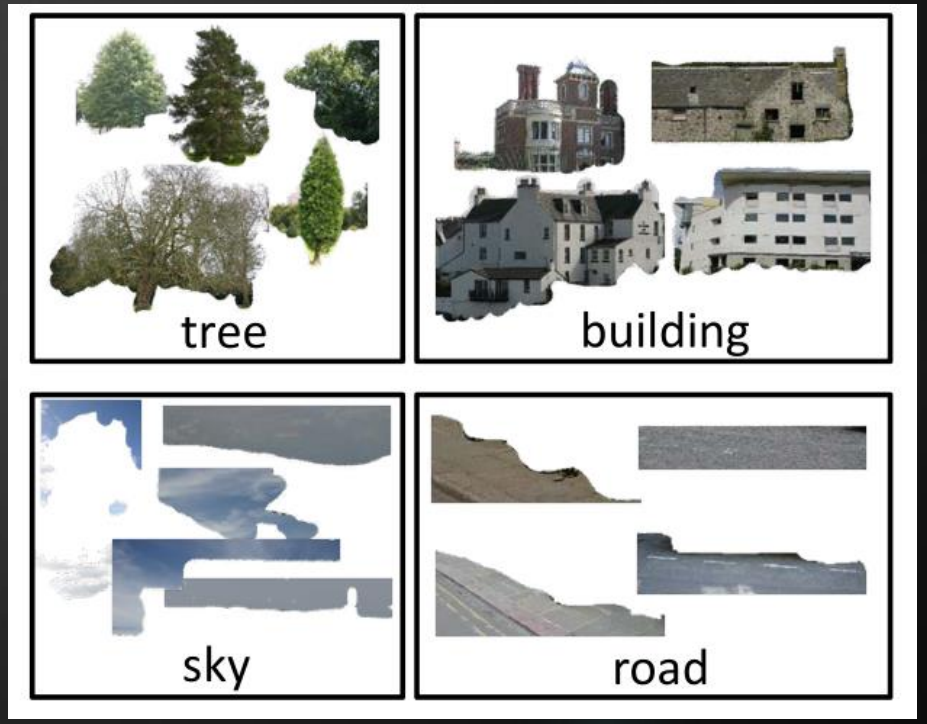


Overview

- Learn category models for some classes
- Detect unknowns
- Describe object-level context using a graph structure
- Group regions to discover new categories

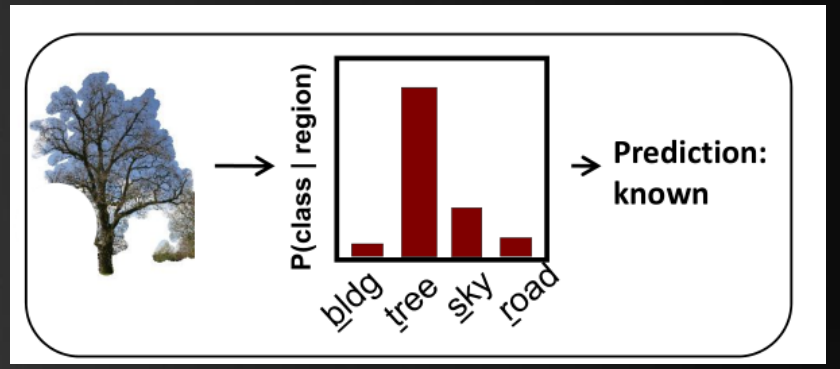
Learn Known Categories

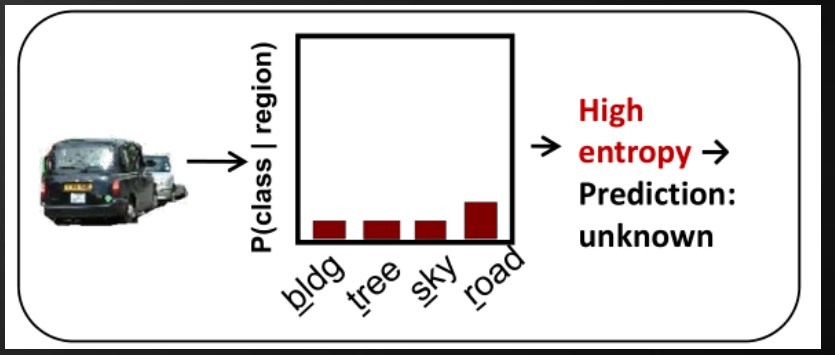
- Texture, color, and shape using multiple kernel learning
- Train SVM classifies for the probability that a segment belongs to a class $P(c|s)$
- Known categories
  - Tree, building, sky, road



Identifying Unknown Objects

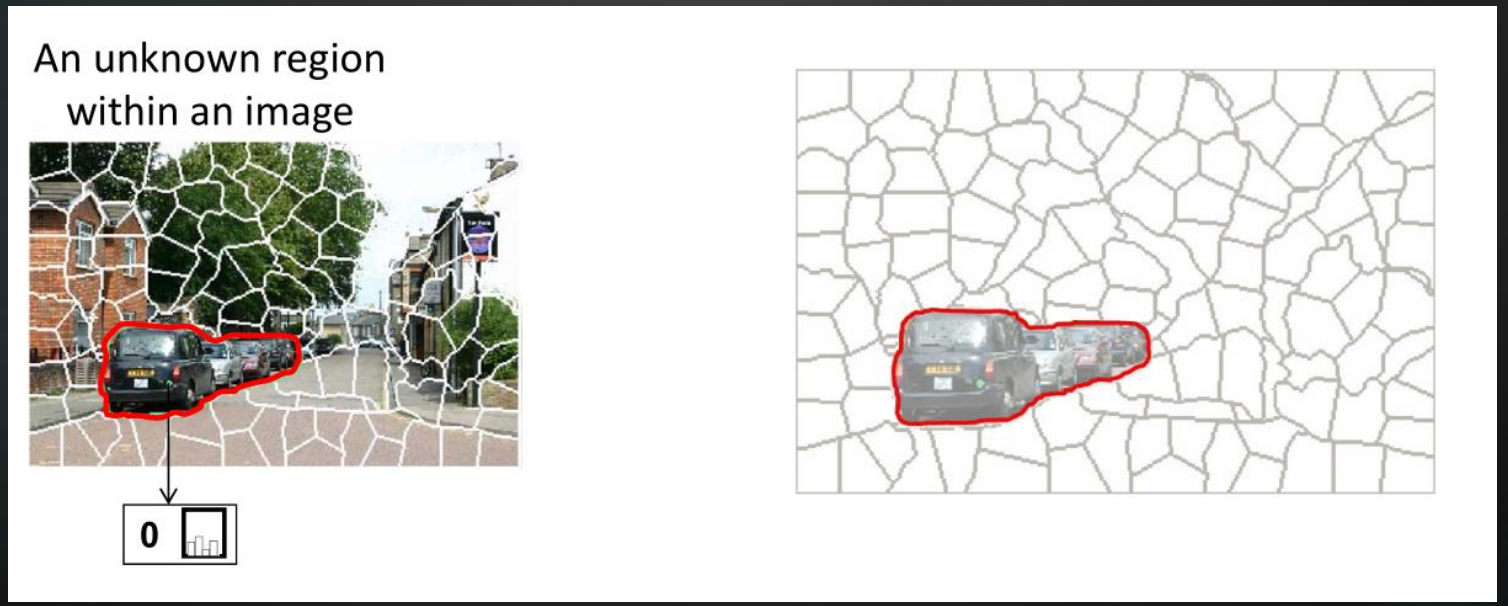
- Compute multiple segmentations
- Run the classifiers that was trained offline
- Compute entropy
  - equation
  - Lower = more confidence
  - Higher = low confidence





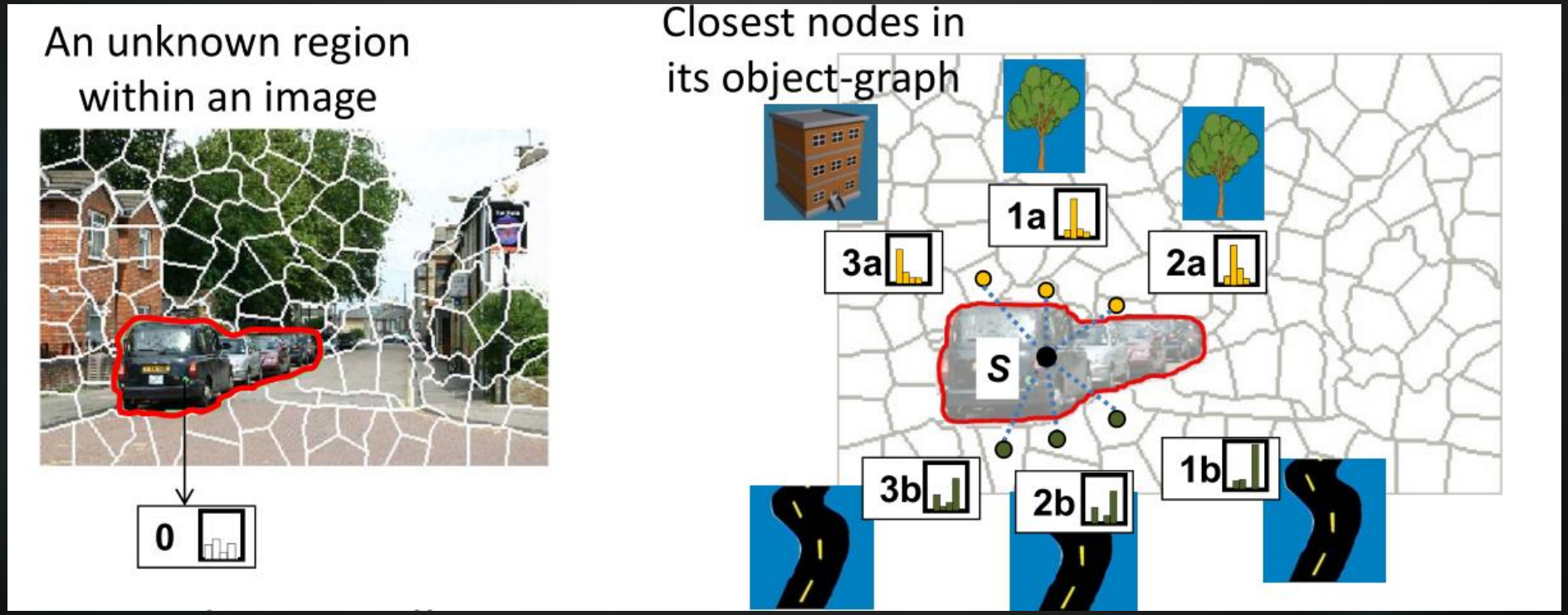
Object Graphs

- Models contextual information surrounding the unknown segment
- Regions with similar context should net similar graph structures
- Compute superpixels
  - Each superpixel is a node in the graph



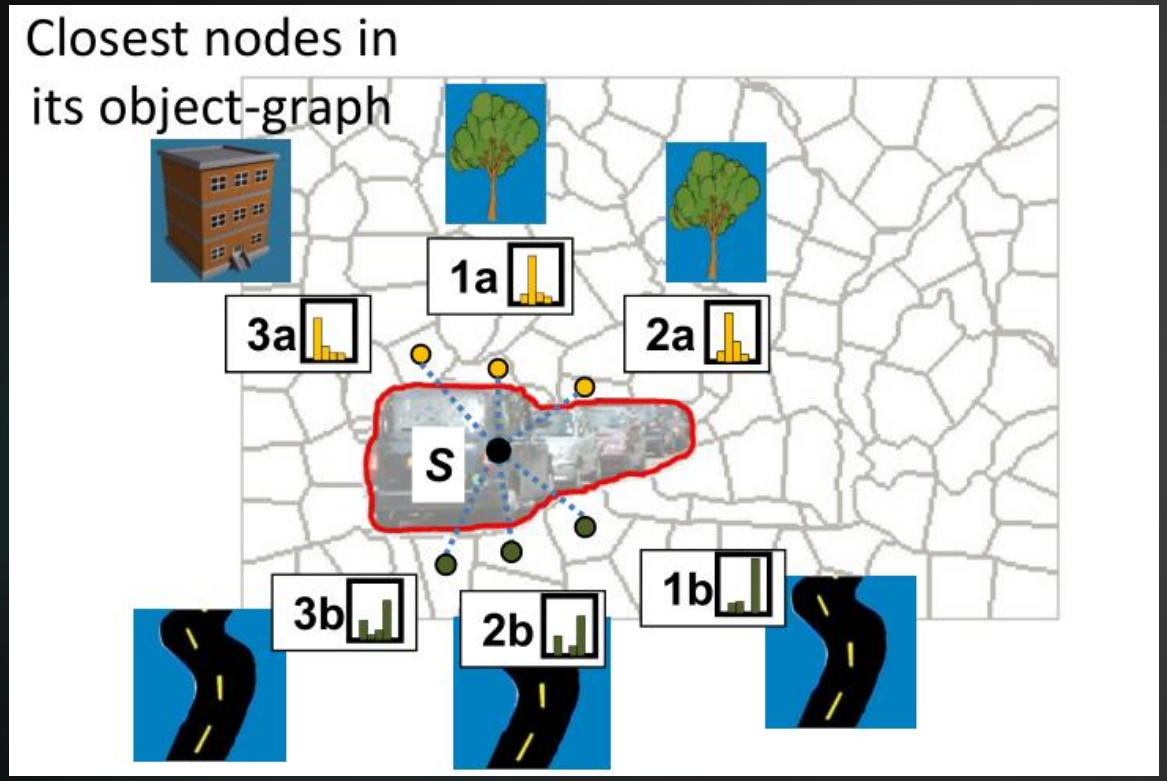
Object Graphs

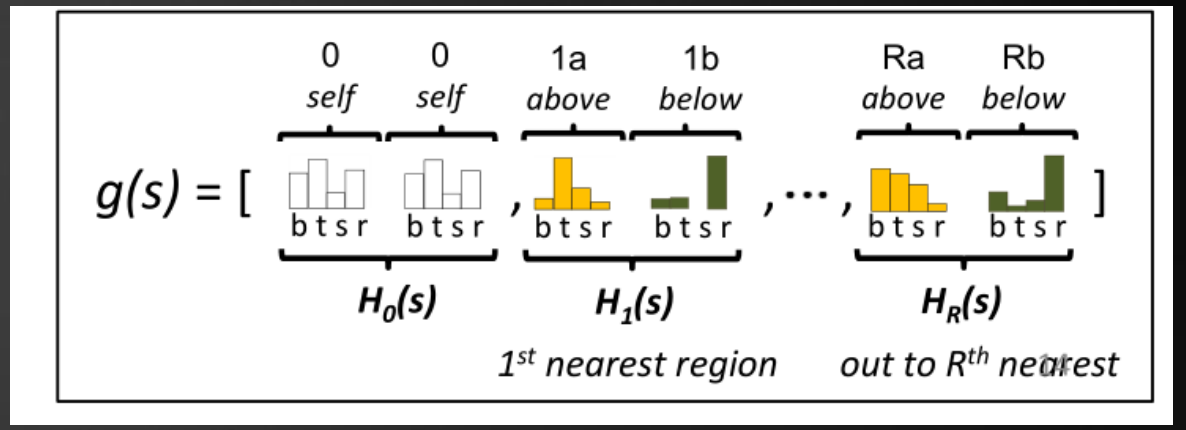
- Compute histograms of superpixels above and below the segment
  - No side superpixels due to the interchangeability of left and right
- Histograms are averages probabilities of occurrence of pixels r distance away



Object Graphs

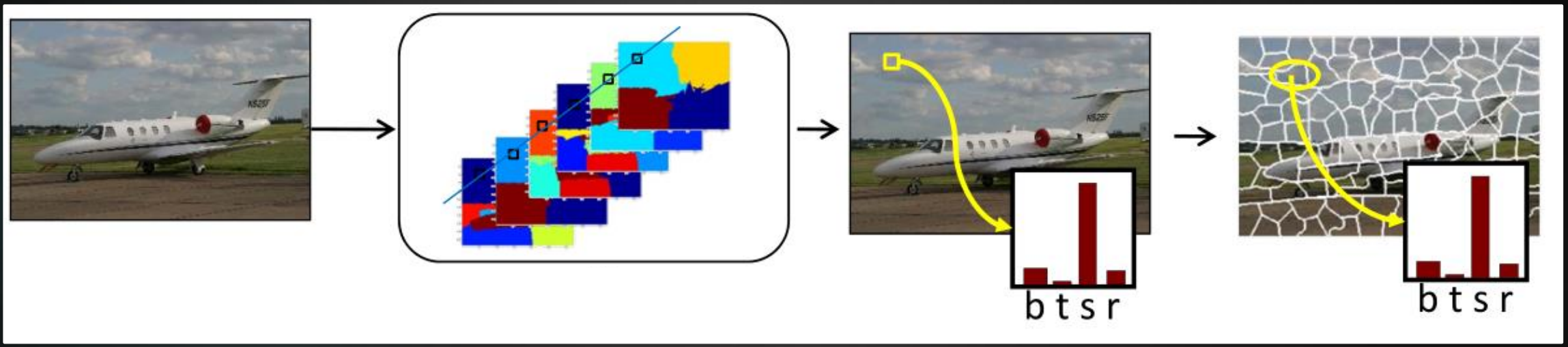
- Concatenate histograms to from a histogram vector



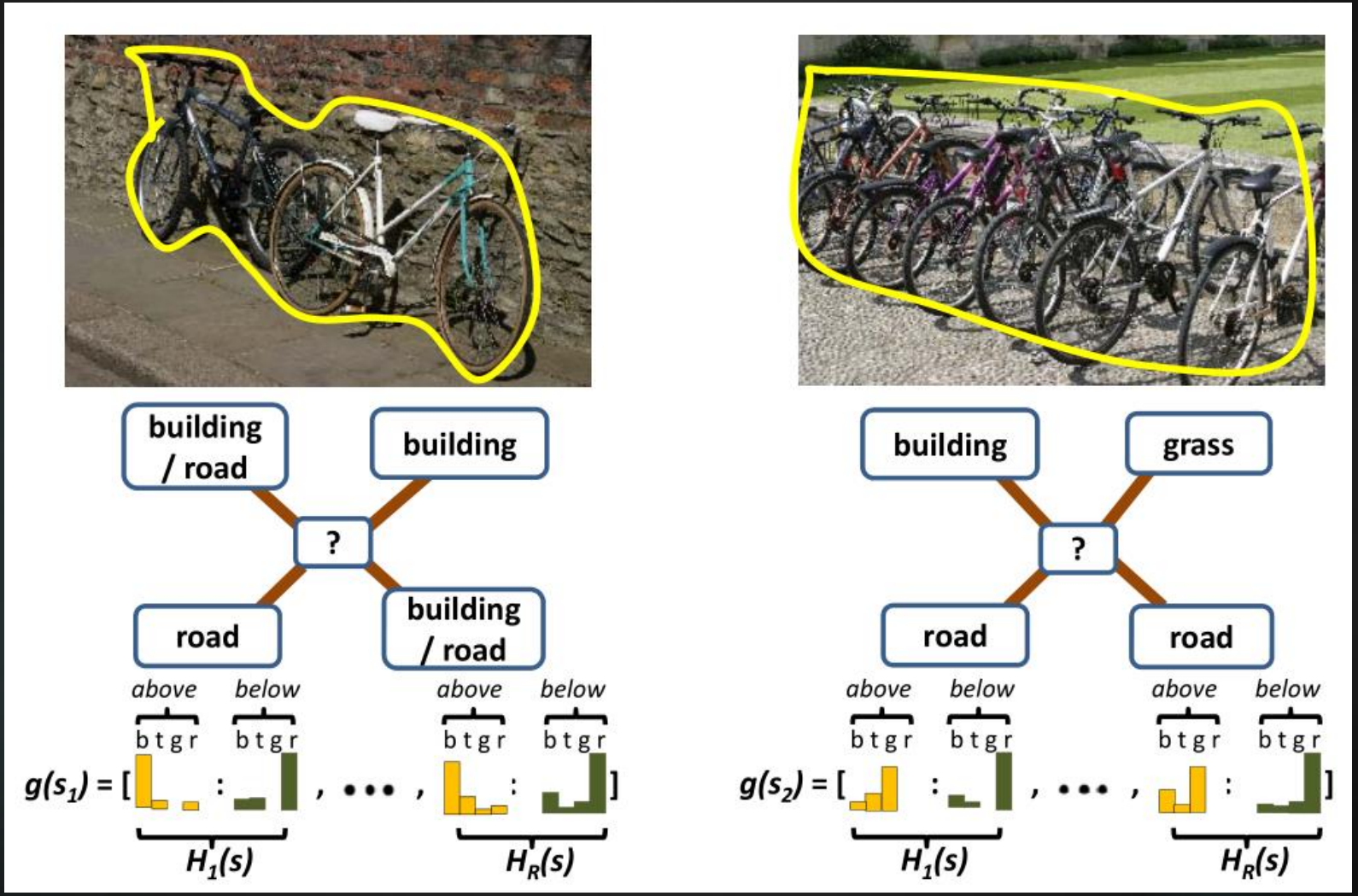


Object Graphs

- Superpixel know object probabilities are computed from multiple segmentations



Example


building / road
building
?
road
building / road
above
below
b t g r
b t g r
b t g r
b t g r
$g(s_1) = [$
:
,
,
:
$]$
$H_1(s)$
$H_R(s)$
building
grass
?
road
road
above
below
b t g r
b t g r
b t g r
b t g r
$g(s_2) = [$
:
,
,
:
$]$
$H_1(s)$
$H_R(s)$

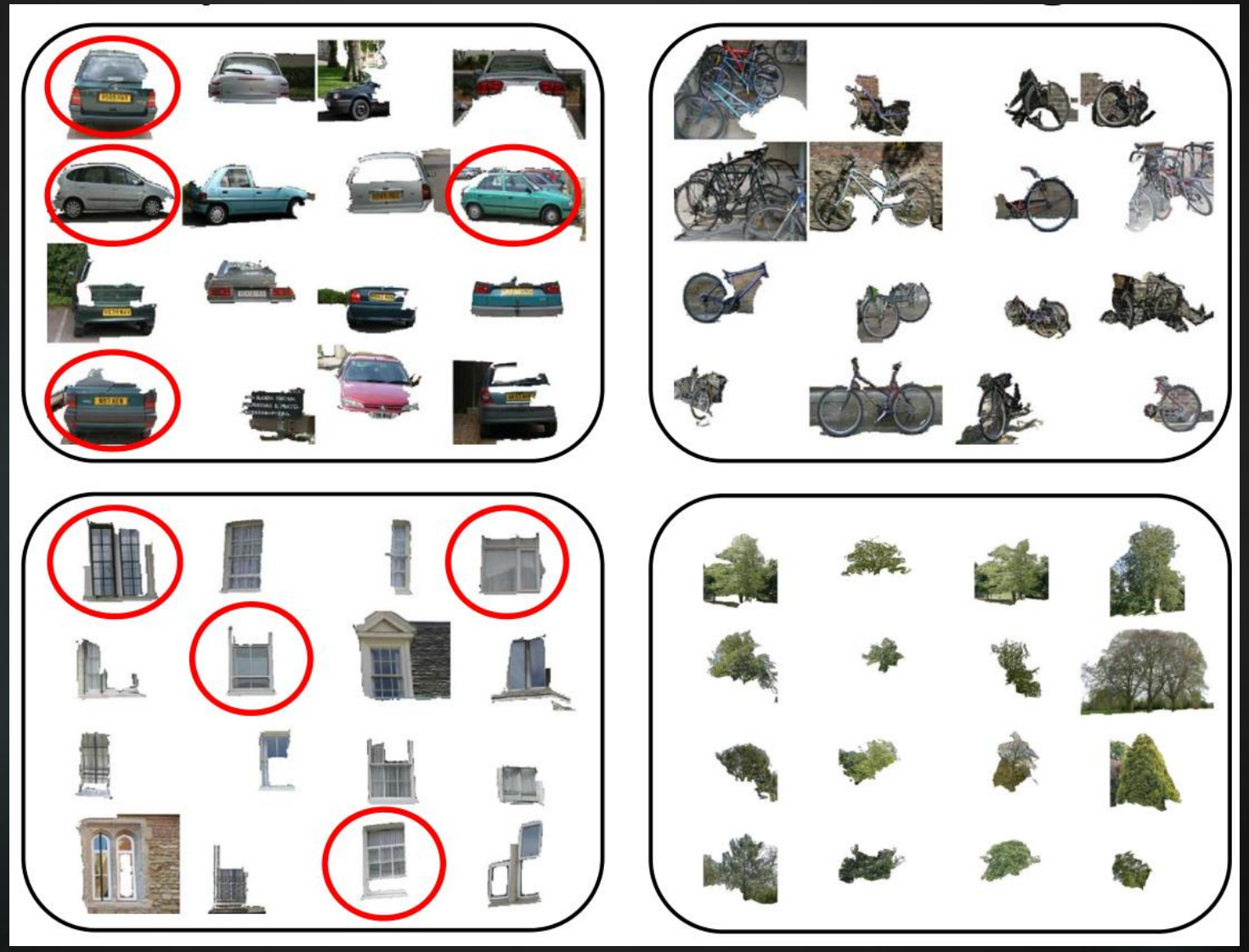
Category Discovery

- Similarity function based on two regions
  - $\mathrm{K}(s_i, s_j) = K_{app}(s_i, s_j) + K_{graph}(s_i, s_j)$
  - Weights can be learned in a unsupervised way
- Appearance based similarity scores
  - bag-of-features histograms
- A affinity matrix is generated between all pairs on unknown regions
- A spectral clustering method is used to cluster

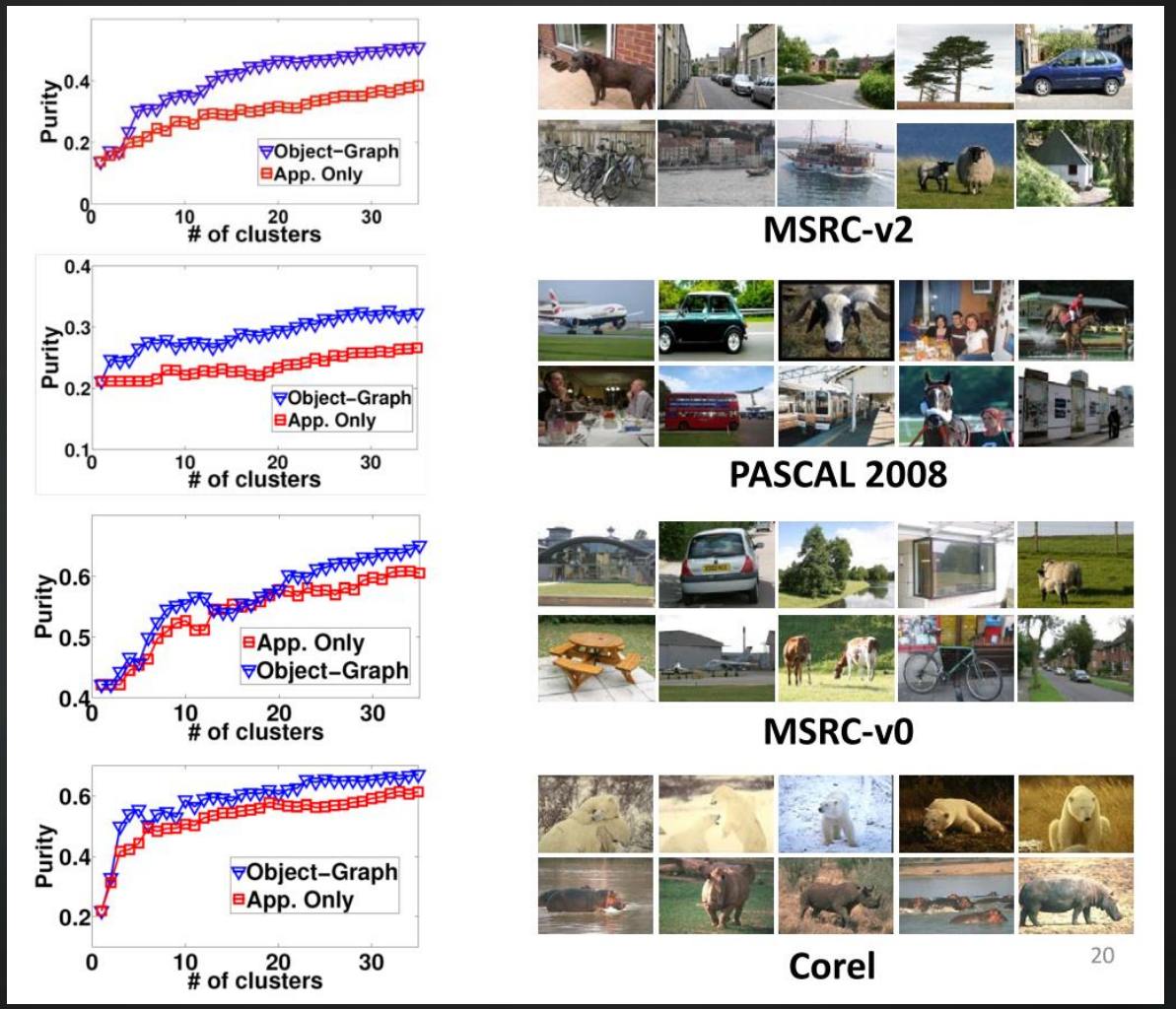
Datasets

- MSRC-v2
  - 21 classes, 591 images
- PASCAL 2008
  - 20 classes, 1,023 images
- MSRC-v0
  - 21 classes, 3,457 images
- Corel
  - 7 classes, 100 images
- Train 40% for known
- Test 60%

Results - Examples



Results - Numbers

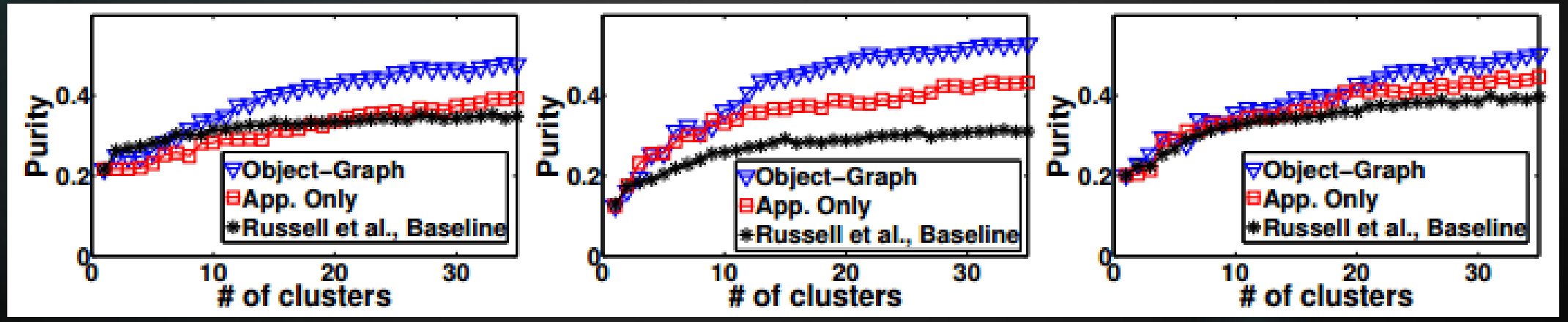


Results - Numbers

MSRC Mean Average Precision

	Building	Tree	Cow	Airplane	Bicycle
Our full model	**0.32**	**0.36**	**0.41**	**0.36**	0.21
App. only	0.27	0.33	0.20	0.21	0.10
Obj-Graph only	**0.32**	0.27	0.37	0.32	**0.24**

MSRC comparison



Discussion