Recognition using Regions
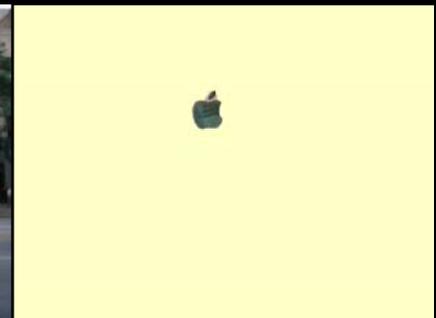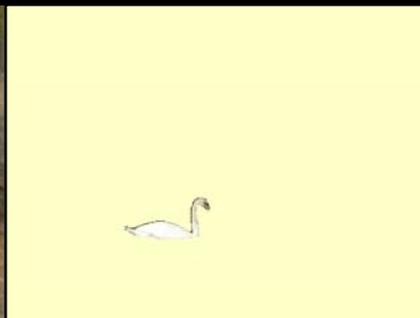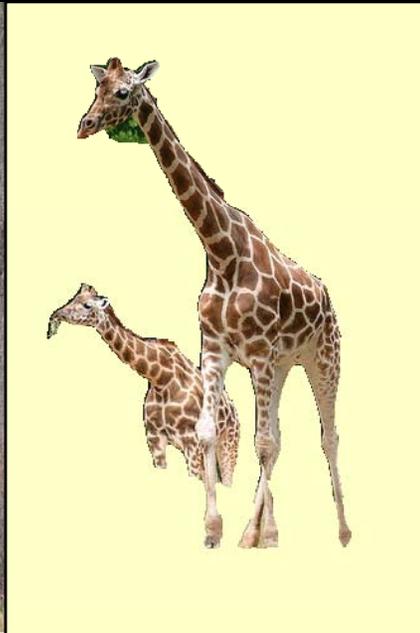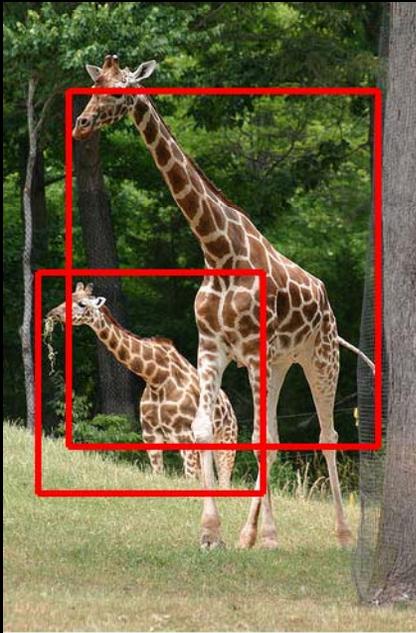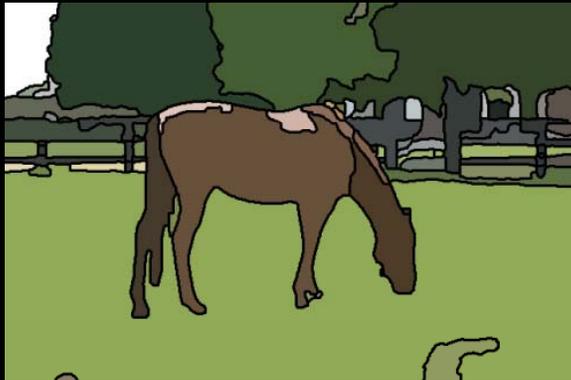
Chunhui Gu, Joseph Lim, Pablo Arbelaez,
Jitendra Malik

University of California at Berkeley

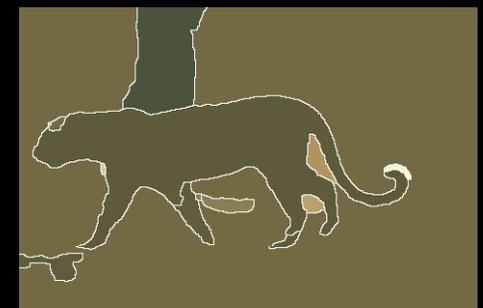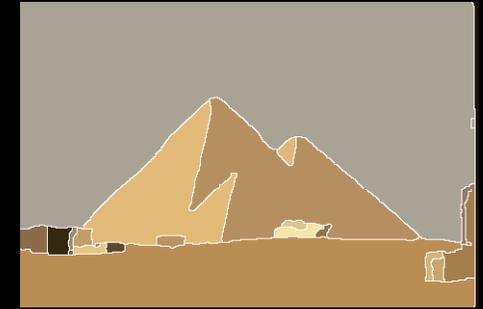# Detection and Segmentation

Regions as Primitives

- Encode object scale
- Encode object shape
- Are robust to clutter

- High-performance detector available
- Robust recognition machinery to errors

Hoiem et al. ICCV 05; Rabinovich et al. ICCV 07;
Todorovic & Ahuja CVPR 08; Malisiewicz & Efros CVPR 08;

High-performance Region Detector
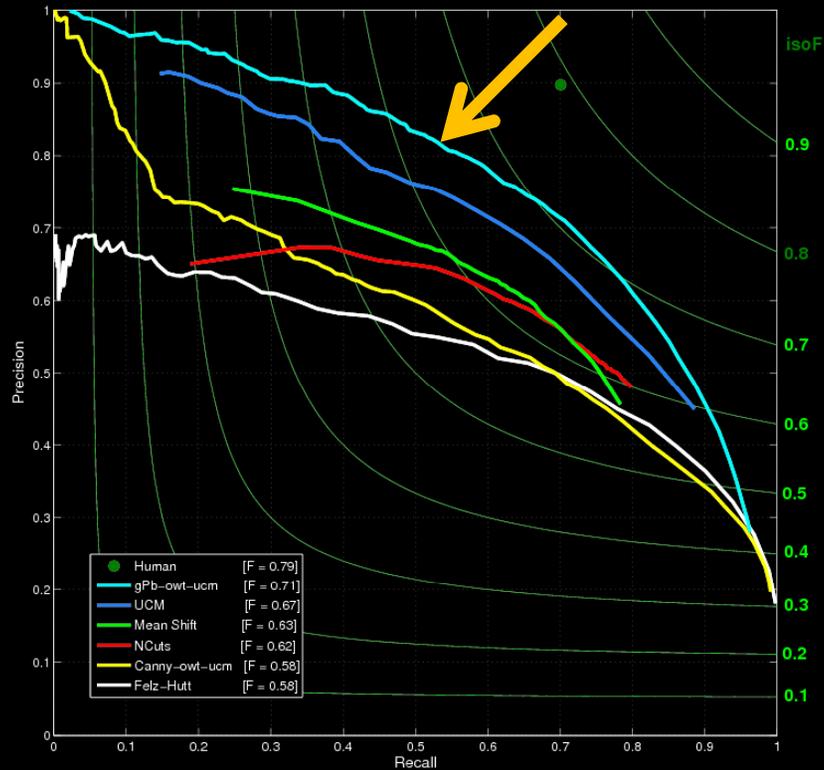
Arbelaez, Maire, Fowlkes, Malik. CVPR 09
Poster session 5

Outline

- Motivation
- **Region Representation**
- Algorithm
- Experimental Evaluation
- Conclusion

Region Tree

Bag of Regions
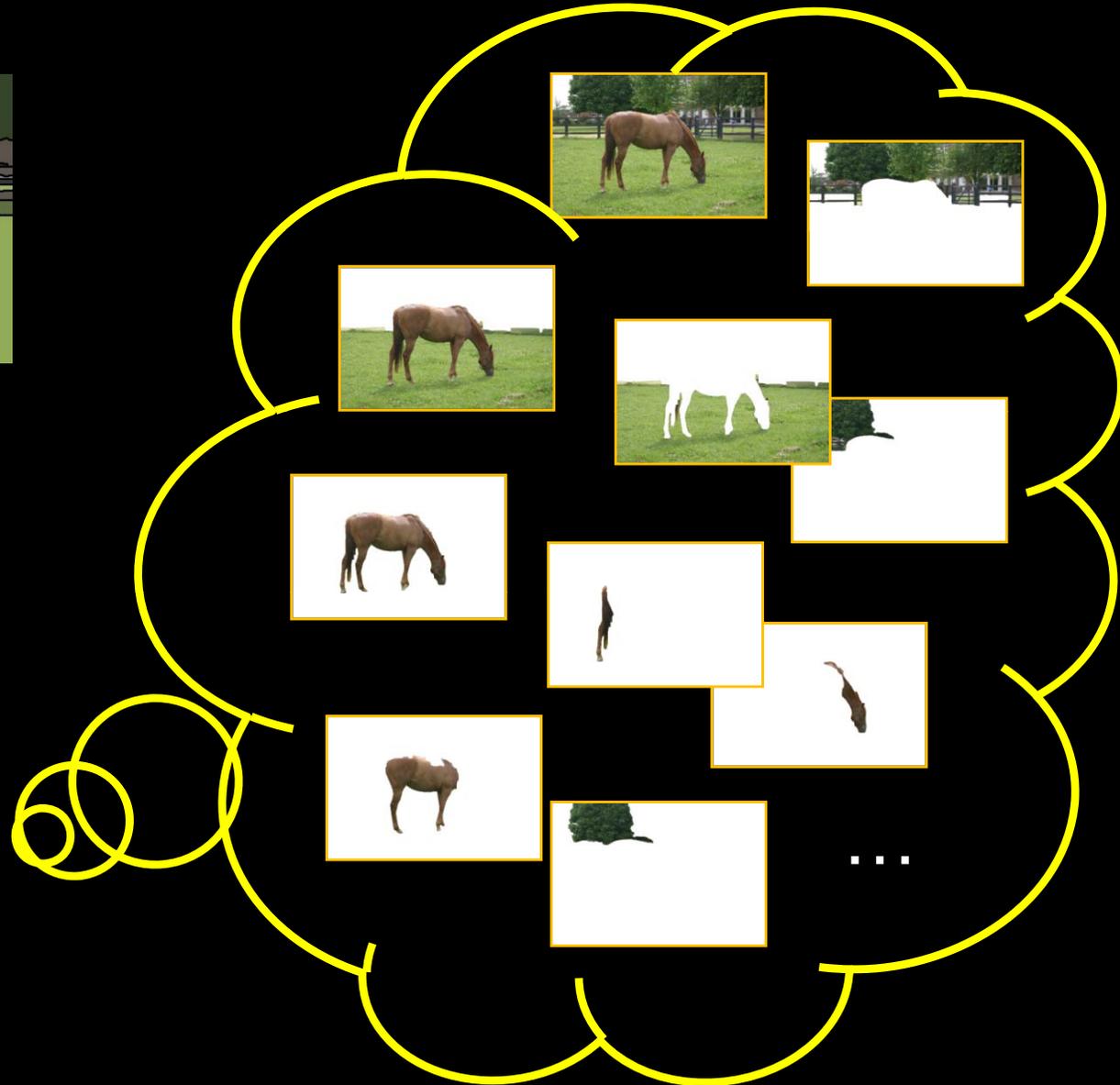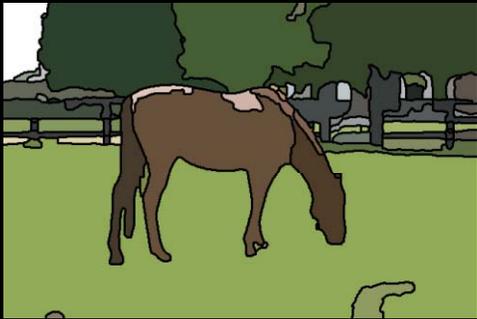
Region Description
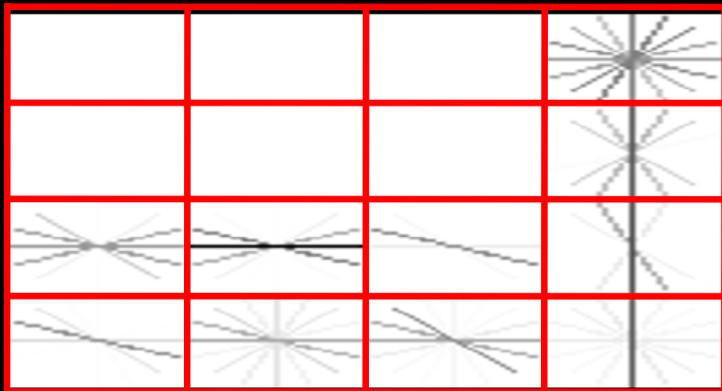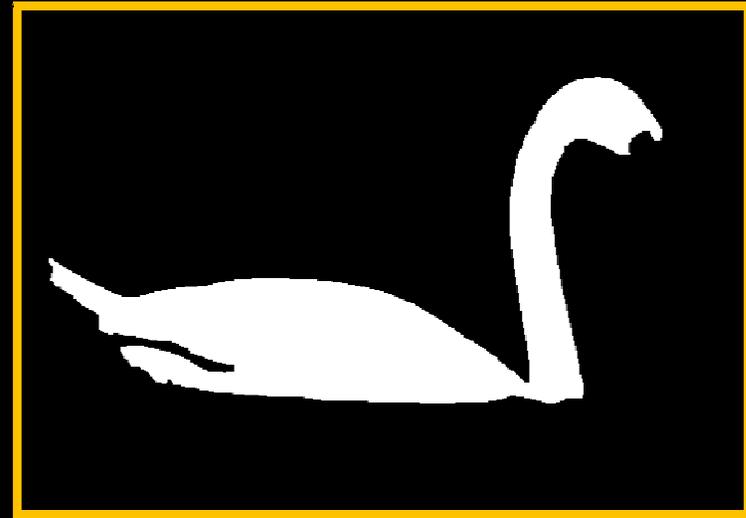
Outline

- Motivation
- Region Representation
- **Algorithm**
- Experimental Evaluation
- Conclusion

Region-based Hough Voting

- Recover transformation from matched regions
- Transform exemplar bounding box to query

$T(x,y,s_x,s_y)$

$T(x,y,s_x,s_y)$
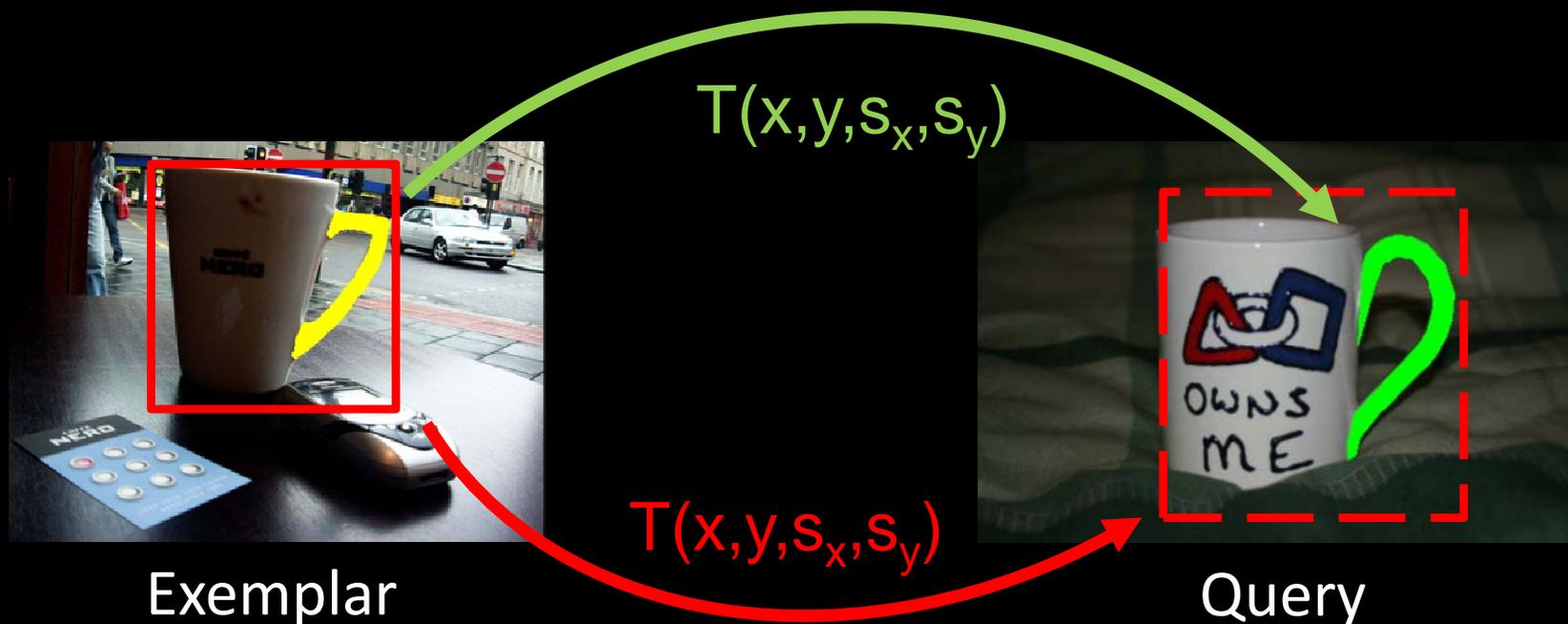
Exemplar

Query

Region-based Voting

Exemplar 1

Exemplar 2

Query
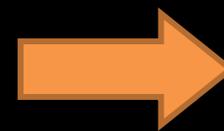
Mean
Shift
Clustering

Query

Algorithm Pipeline

Exemplars

Images

Ground truths

Weight learning

Region matching based voting

Query

Initial Hypotheses
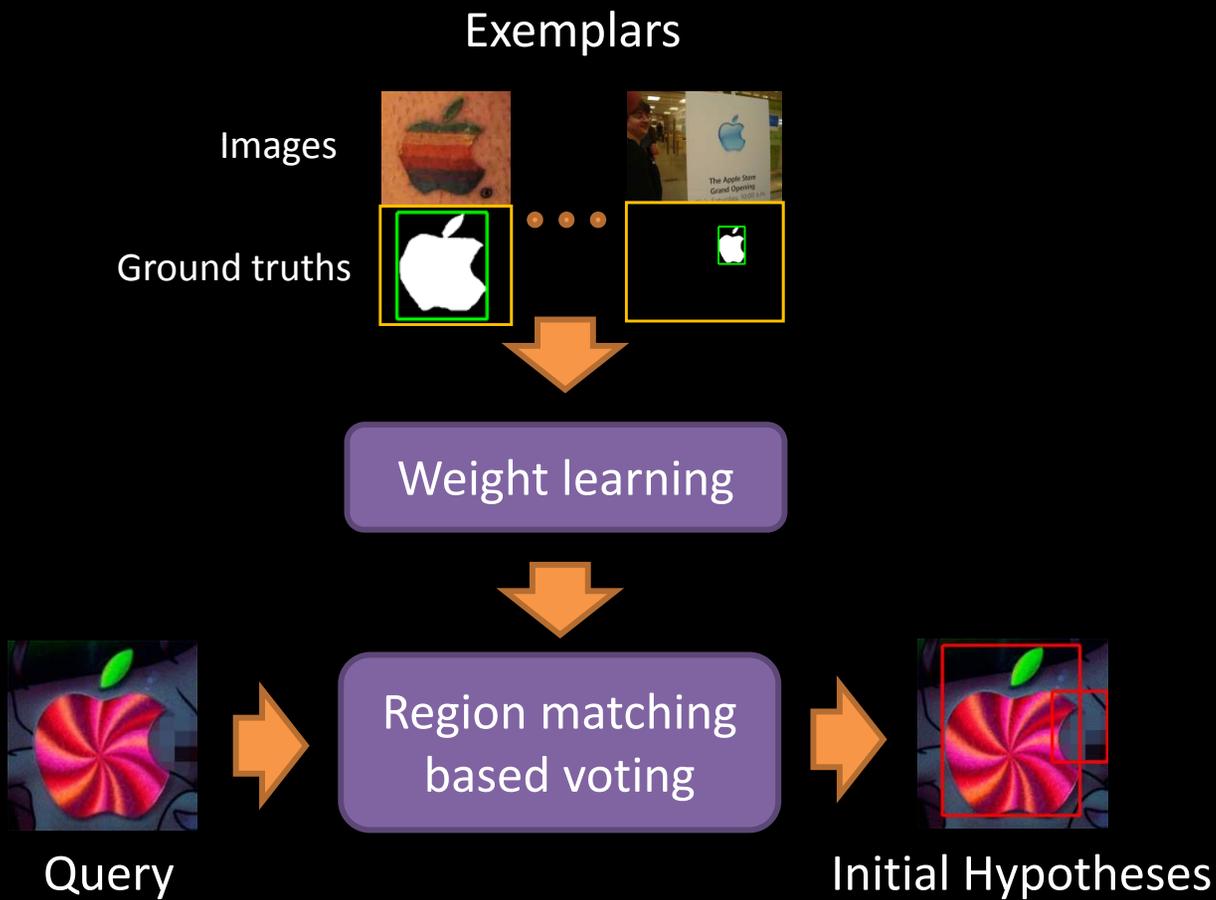
Weight Learning - Formulation

Exemplar *J*   Exemplar *I*   Exemplar *K*

$D(I,J)$ $D(I,K)$

Define: $D(I,J) = \Sigma_i\, w_i \cdot d_i^J$

Want: $D(I,K) > D(I,J)$

Max-margin formulation results in a sparse solution.

Frome, Singer & Malik. NIPS 06

Weight Learning - Results

- Sparse (<30%), non-repeatable regions are removed

More Discriminative ⟷ Less Discriminative

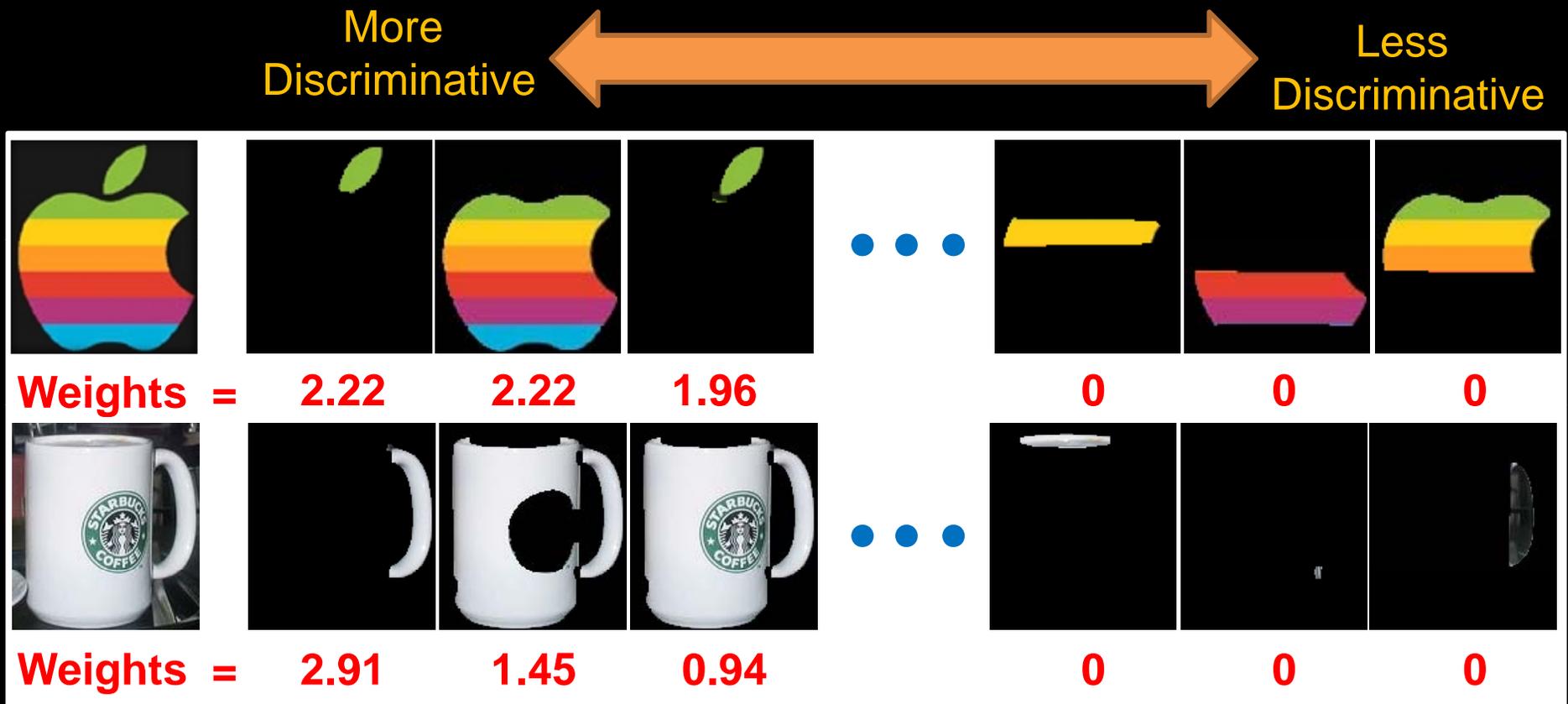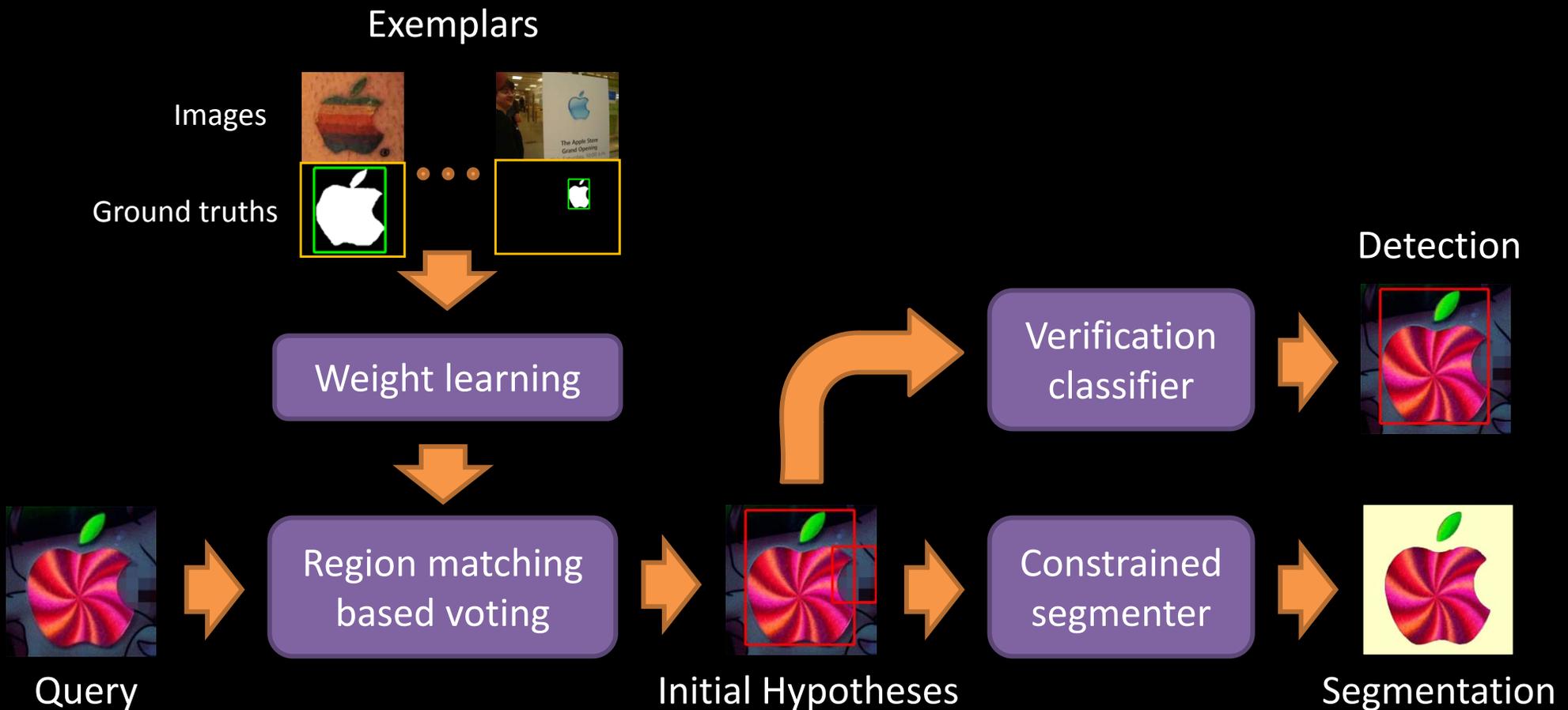|							
Weights =	**2.22**	**2.22**	**1.96**		**0**	**0**	**0**
Weights =	**2.91**	**1.45**	**0.94**		**0**	**0**	**0**

Algorithm Pipeline

Exemplars

Images

Ground truths

Weight learning

Region matching based voting

Query

Initial Hypotheses

Verification classifier

Detection

Constrained segmenter

Segmentation

Initial Object/Background Labels

Exemplar

Transformed Mask

Query

Matched Part

Initial Labels

+

🟩 : Object label
🟥 : Background label
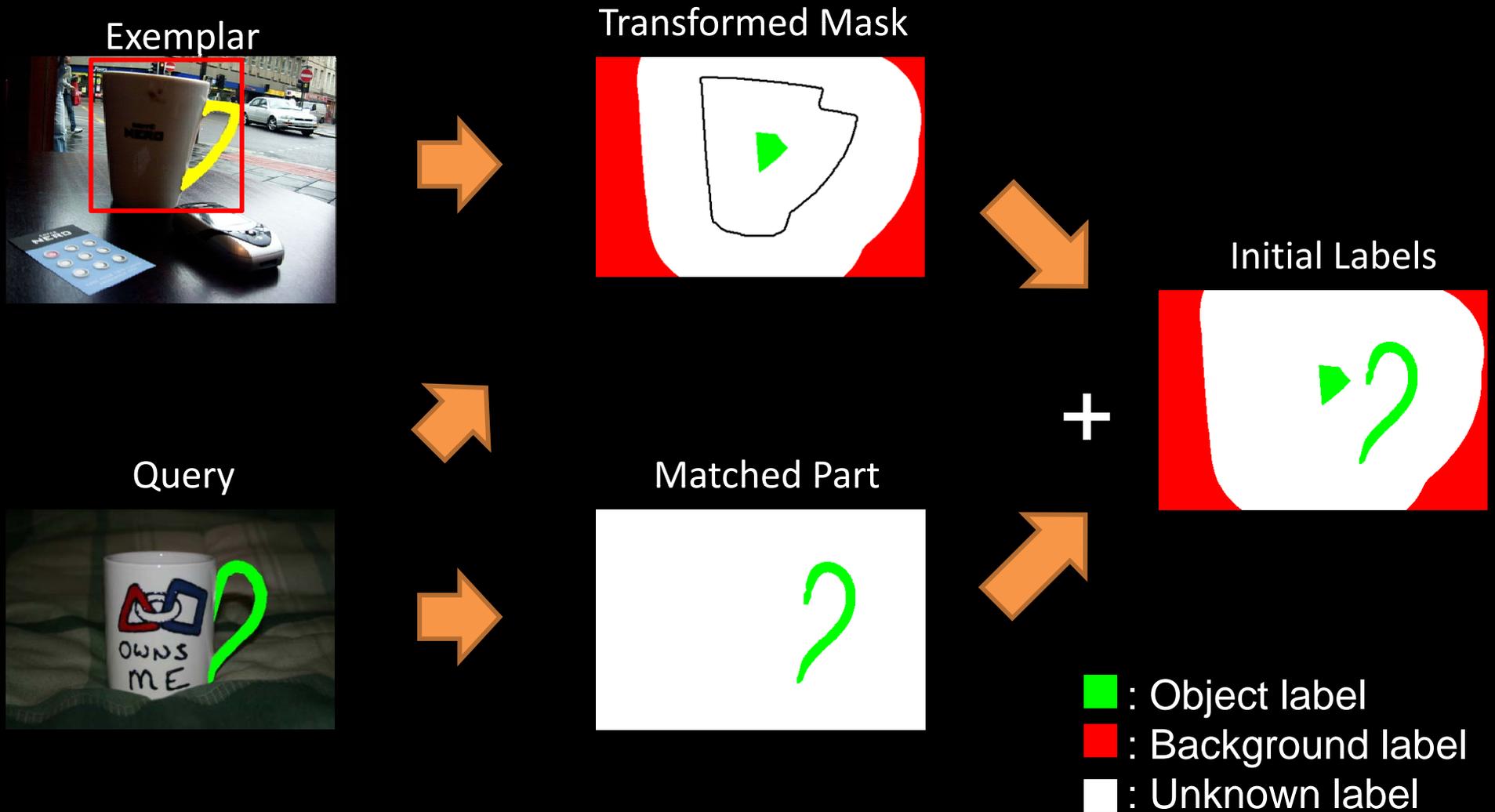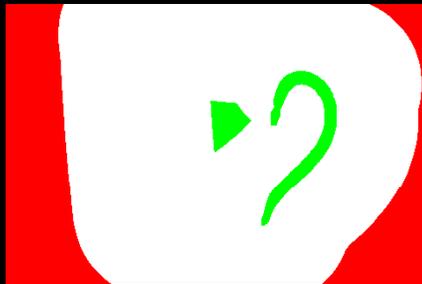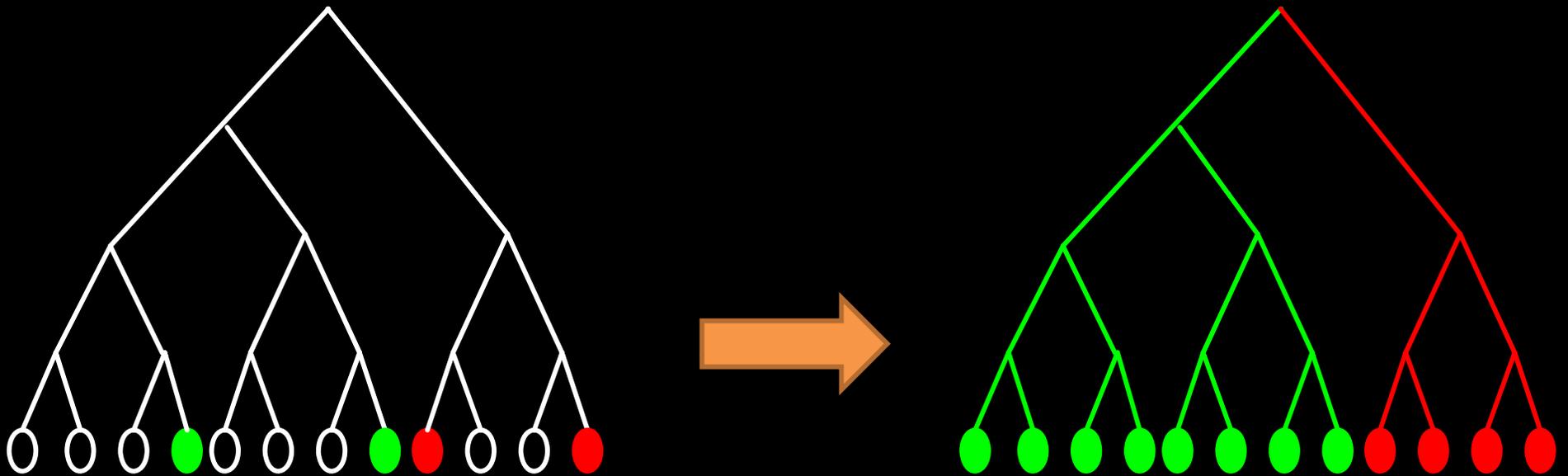⬜ : Unknown label

Fully automatic unlike interactive use of Graph Cuts, e.g. Blake et al. ECCV 04

Propagate Object/Background Labels
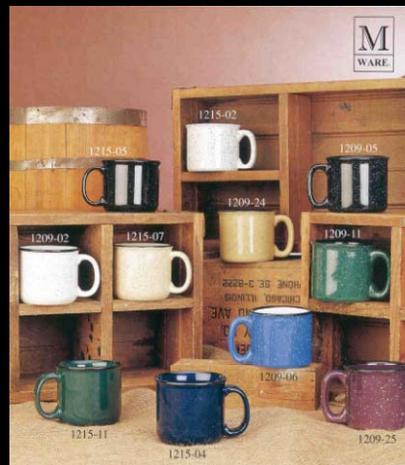

Initial Labels

Final Segmentation
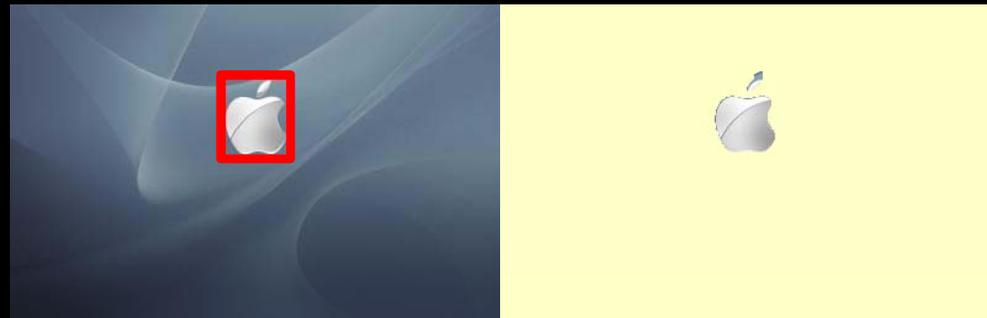
Arbelaez and Cohen. CVPR 08

Outline

- Motivation
- Region Representation
- Algorithm
- **Experimental Evaluation (ETHZ shape, Caltech 101)**
- Conclusion

ETHZ Shape (Ferrari et al. 06)
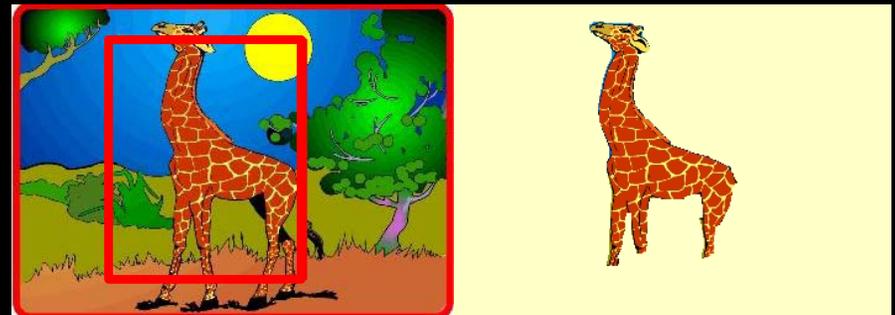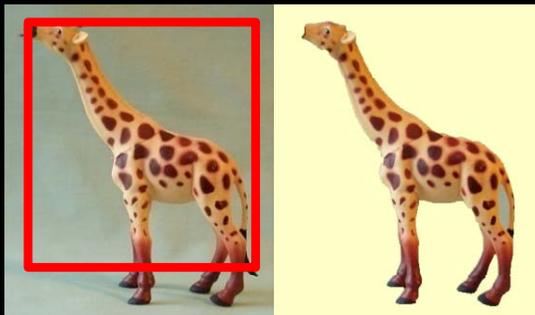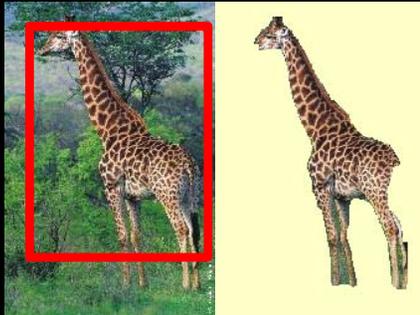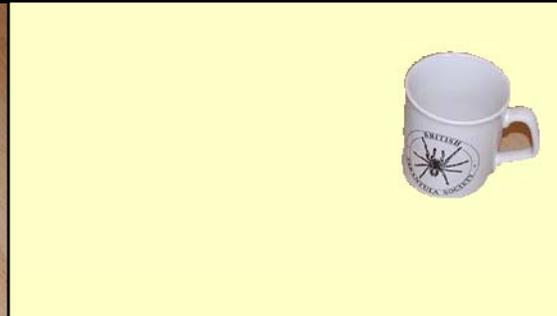
- 255 images of 5 diverse shape-based categories.

Applelogos

Bottles

Giraffes

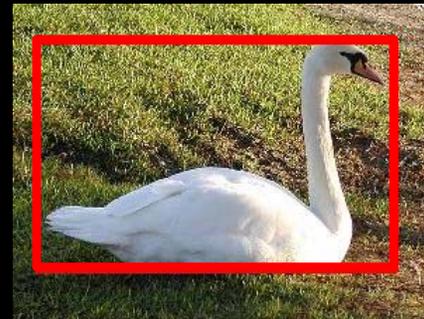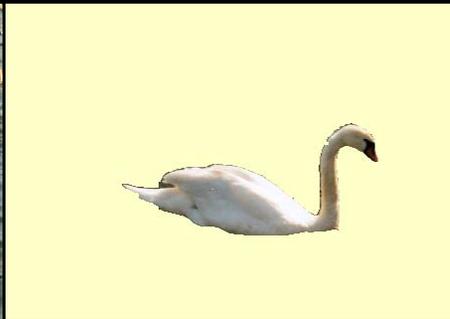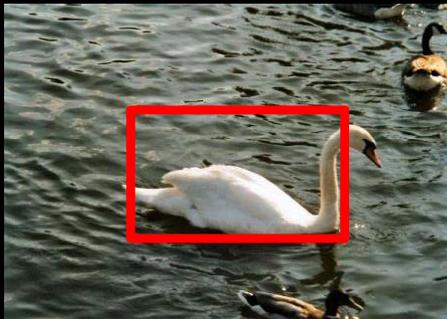# Mugs

Swans
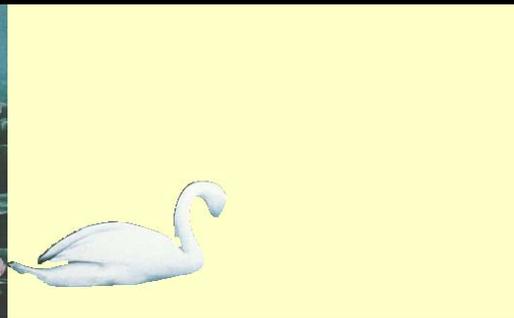
Results

Detection: (recall at 0.3 fppi, Pascal criterion)

Method	Ferrari et al. 07	Voting only	Voting + Verify
Recall Rate (%)	67.2	82.9±4.3	87.1±2.8

Segmentation: (pixel-wise average precision)

Method	Bounding box	Segmenter
AP Rate (%)	51.6±2.5	75.7±3.2

All results are averaged over 5 training/test splits.

Results

Number of windows compared to window scanning:

Categories (#)	Scanned windows	Regions	Bounding boxes
Applelogos	~30,000	115	3.1
Bottles	~1,500	168	1.1
Giraffes	~14,000	156	6.9
Mugs	~16,000	189	5.3
Swans	~10,000	132	2.3

All results are averaged over 5 training/test splits.

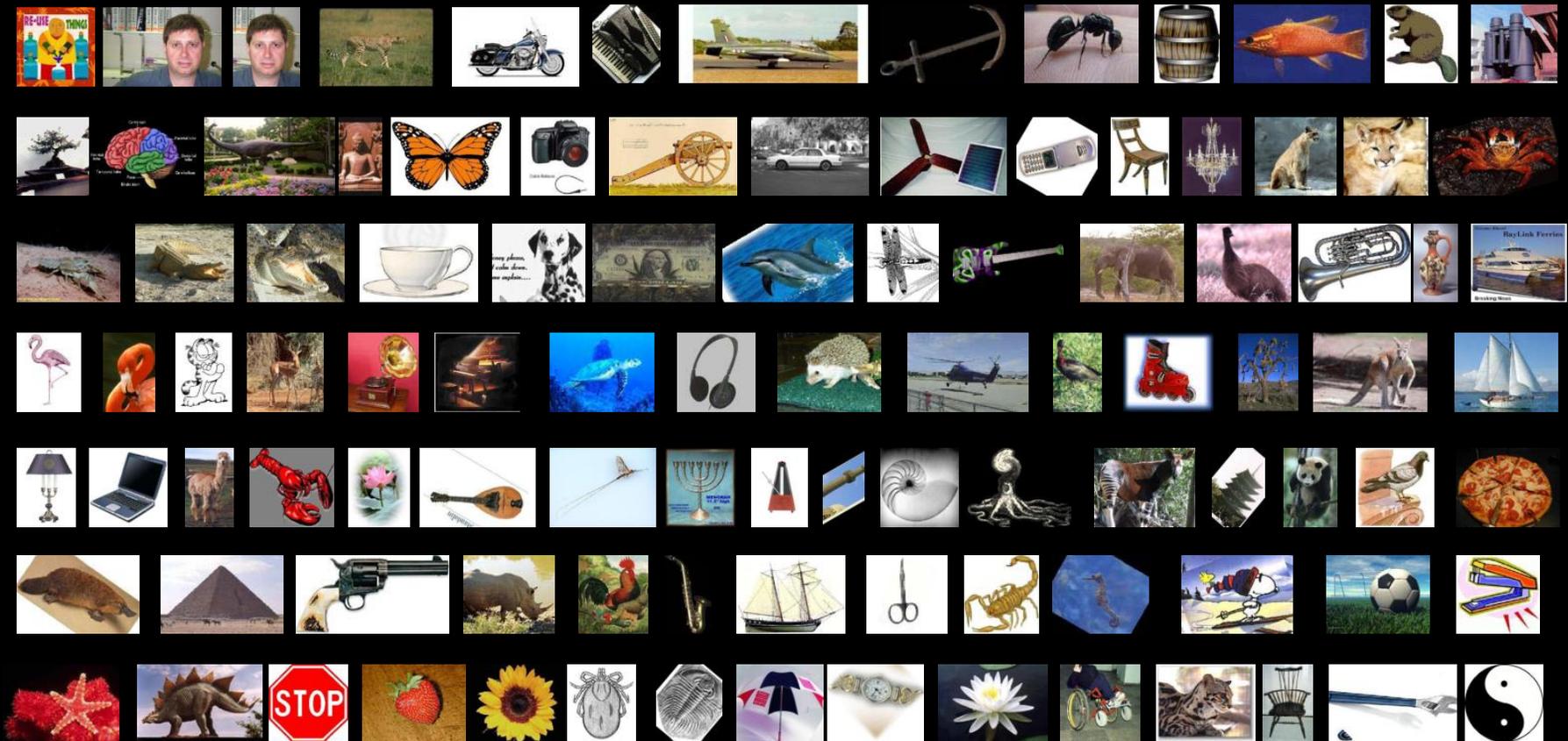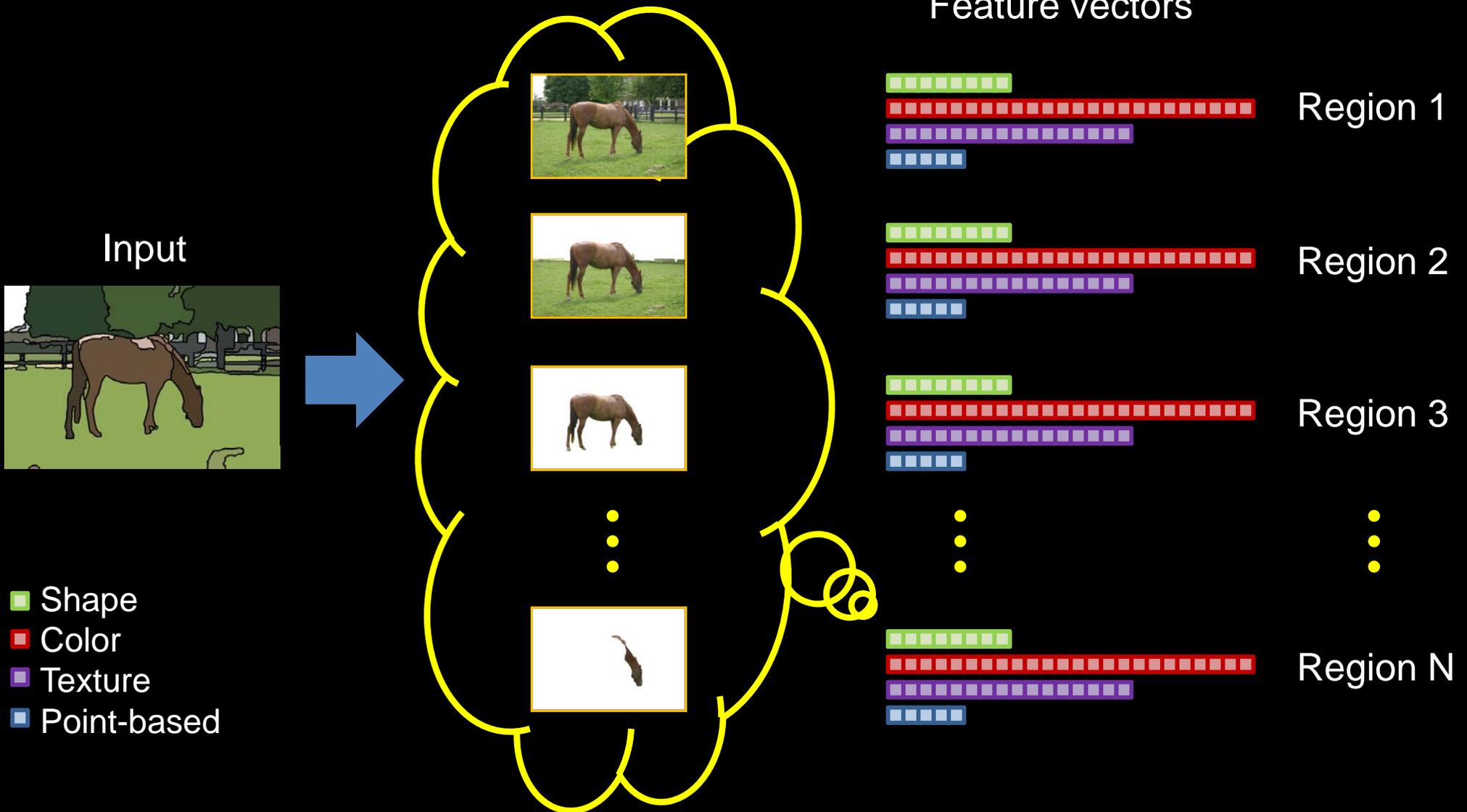# Caltech 101 (Fei-Fei et al. 04)

- 102 classes, 31-800 images/class

Image Representation

Feature vectors

Input

Region 1

Region 2

Region 3

Region N

■ Shape
■ Color
■ Texture
■ Point-based

Performance with cue combination

Image Cues	15 train (%)	30 train (%)
(R) Shape (contour)	55.1	60.4
(R) Shape (edge)	42.9	48.0
(R) Color	27.1	27.2
(R) Texture	31.4	32.7
(R) Combination	59.0	65.2
(IP) Geometric Blur	58.4	63.2
(R) Shape + (IP) GB	65.0	73.1

Conclusion

- Introduce a novel Hough voting scheme using *REGIONS* as primitives

- Solves detection and segmentation in a combined framework

- Cue combination improves recognition performance

Code is available!
http://www.eecs.berkeley.edu/chunhui/cvpr09_v1.zip

Thank you!