Unsupervised Classification and Part Localization by Consistency Amplification

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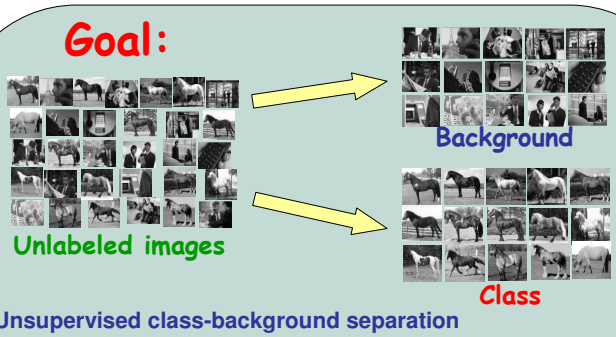
Goal:



- Unsupervised class-background separation
- Unsupervised category learning
- Building a class model

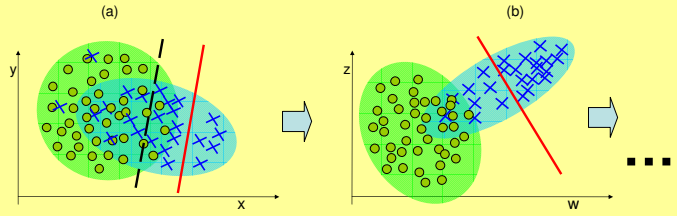
Challenge:

- *Completely* unlabeled, uncropped and unaligned images
- Inner class objects variability
- Small amount of class images relative to non-class images
- Small object size relative to the background

We propose:

- Combined iterative search for features and a classifier
  - Use of intermediate classification result as internal supervision for subsequent iterations
- Use of both appearance and part-geometry information
  - Discovery of part specific features (PSF)
  - Class-geometry model of object parts

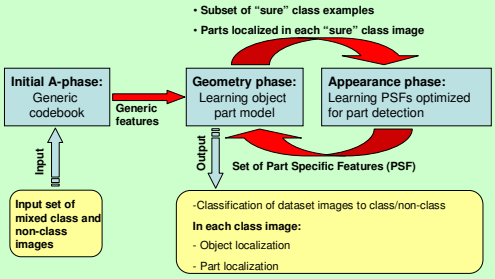
General framework:



Feature re-extraction approach:

- In initial feature space (x-y) it is difficult to separate class (blue crosses) and non-class (green circles) examples.
- (a) Instead of looking for the best separating hyperplane (black dashed line), a subset of *sure class examples* is identified (red line).
- (b) Using this examples the method extracts new feature set (w-z), in which a larger set of class examples can be identified (red line).
- The process then continues iteratively.

Diagram of Unsupervised Consistency Amplification (UCA) Method:



Two main tools for iterative combined search:

- Appearance phase: extraction and combination of different part appearances into PSFs, optimized to have lower scores at incorrect locations on the class objects and in non-class detections
- Geometry phase: training of a part geometry model that allows to select sure class examples and to localize parts on the class objects

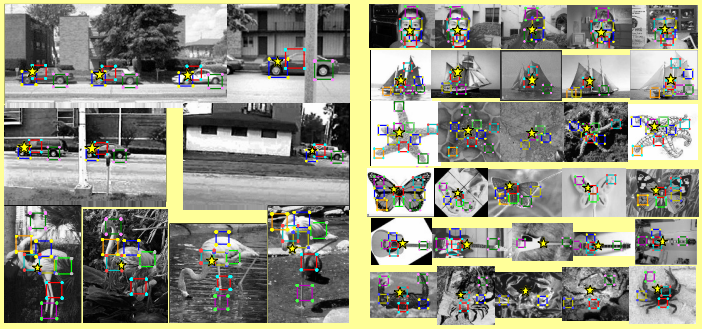
Results

Class-background separation. Datasets: Caltech 101 (various categories), UIUC cars (uncropped unaligned test images), Weizmann horses.

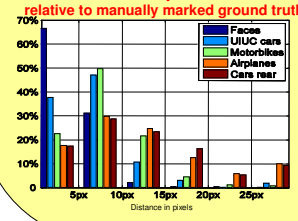
Dataset	Origin	Total number of images	% class images in the set	Object size rel. to bgrnd.	UCA EER, %
Horses	Weizmann	646	50%	35%	2.7
Cars	UIUC	340	50%	3.5%	3.1
Car views	PASCAL	201	50%	40%	10.7
Motorbikes	Caltech-5	900	50%	30%	2.3
Airplanes	Caltech-5	900	50%	20%	2.7
Faces	Caltech-5	900	50%	20%	2.4
Cars-rear	Caltech-5	900	50%	20%	3.2
Bonsai	Caltech101	256	50%	35%	4.1
Ewer	Caltech101	283	30%	34%	2.3

Dataset	Origin	Total number of images	% class images in the set	Object size rel. to bgrnd.	UCA EER, %
Butterfly	Caltech101	303	30%	27%	6
Cars	Caltech101	600	20%	12%	1.1
Crab	Caltech101	365	20%	24%	10.9
Starfish	Caltech101	430	20%	11%	12.6
Laptop	Caltech101	405	20%	32%	4.3
Flamingo	Caltech101	335	20%	13%	7.3
Watch	Caltech101	1139	20%	40%	3.9
Guitars	Caltech101	650	10%	35%	8.2
Schooner	Caltech101	650	10%	27%	6.69

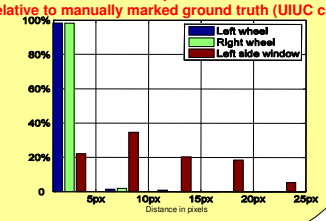
Examples of object and part localization.



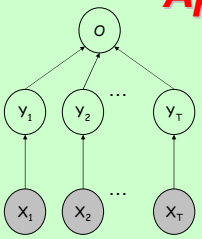
Evaluation of object localization relative to manually marked ground truth



Evaluation of part localization relative to manually marked ground truth (UIUC cars)



Appearance Phase:



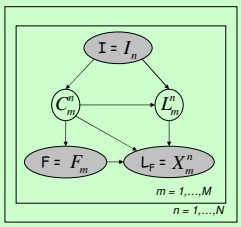
Continuous Noisy-Or model

Method Description

- Extraction of different part appearances
- Joint alignment of the extracted part appearances
- Extraction of a subset of representative part appearances and further optimization for part detection by training of probabilistic discriminative Continuous Noisy-Or (CNOR) model.

Output: a new set of part-specific features

Geometry Phase:



Geometry phase model

Method Description

- Novel version of star-like geometry model
- Modeling both class and background geometry
- For every observed sample (Image, Feature) there is separate reference point drawn from the same distribution.
- Model is trained by EM, which is initialized randomly.

Output: Layout of object parts, sure class examples