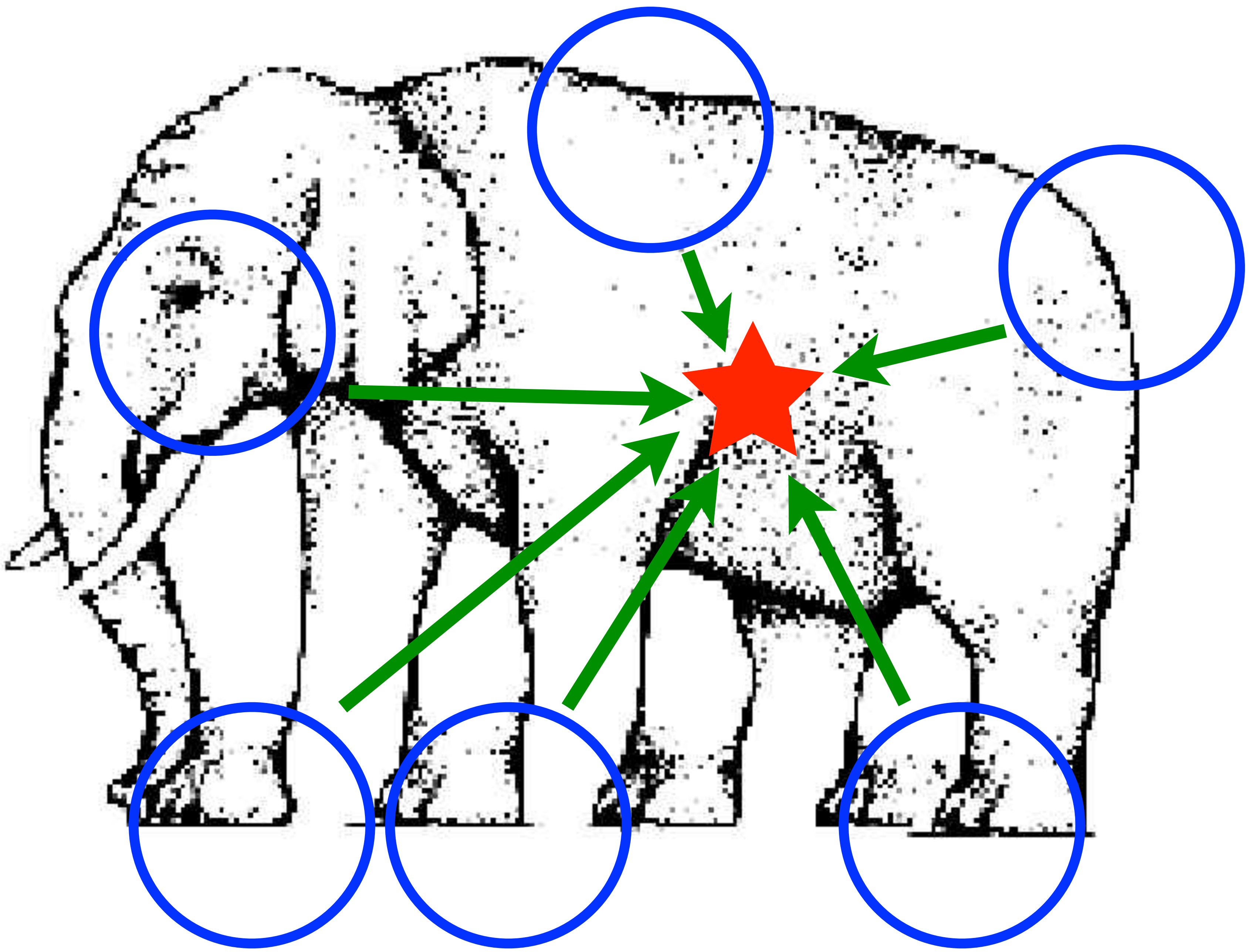
Combining Generative and Discriminative Approaches for Visual Object Class Detection

Mario Fritz

Overview
Lecture on 3rd March

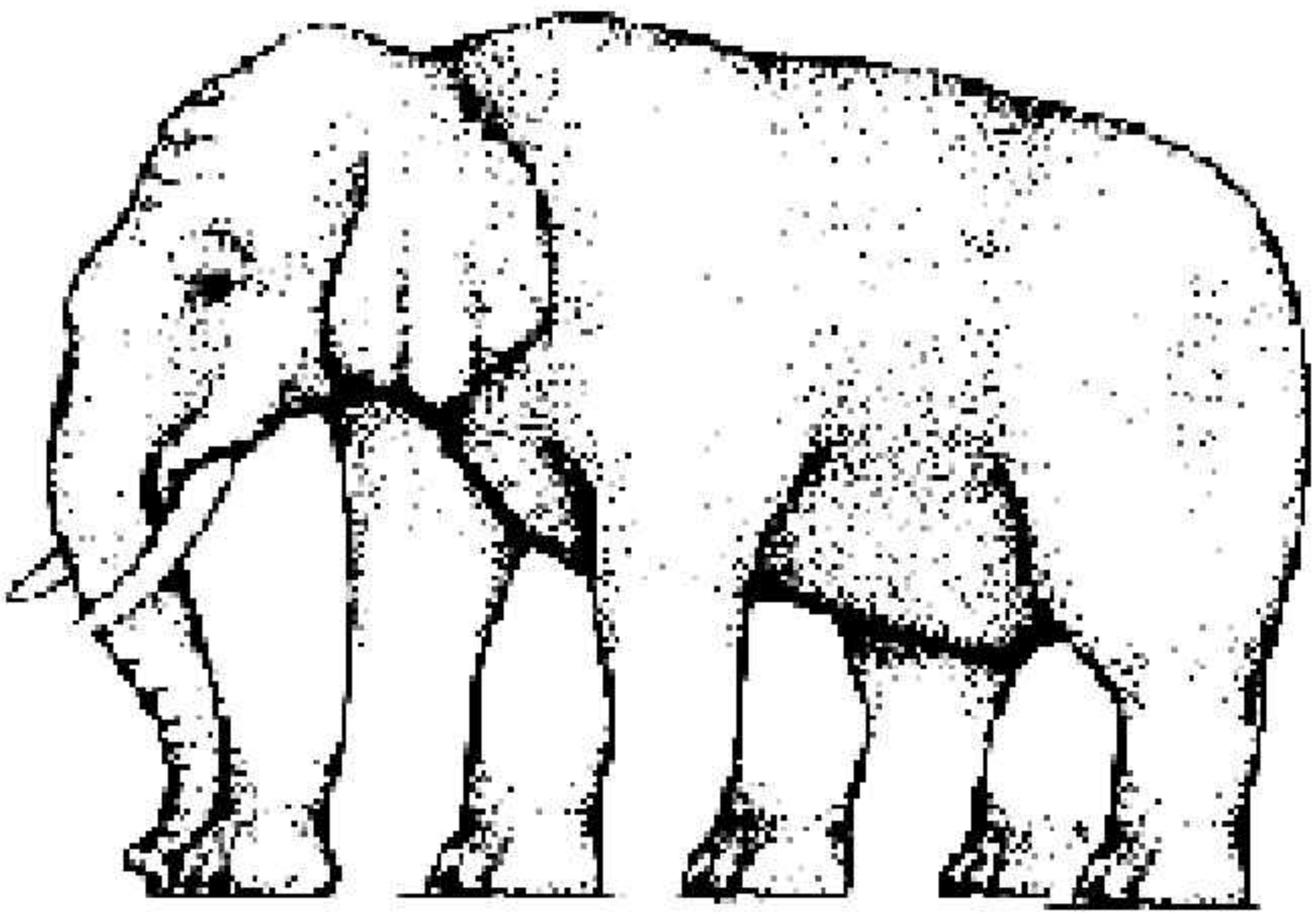
- Motivation from last lecture
  - local vs. global problem
- Recovering global consistency
  - global silhouette verification
- Adding discriminance to the model
  - generative/discriminative model

Complexity of Recognition: Local vs. Global



star model

Complexity of Recognition: Local Voting vs. Global Cosistency



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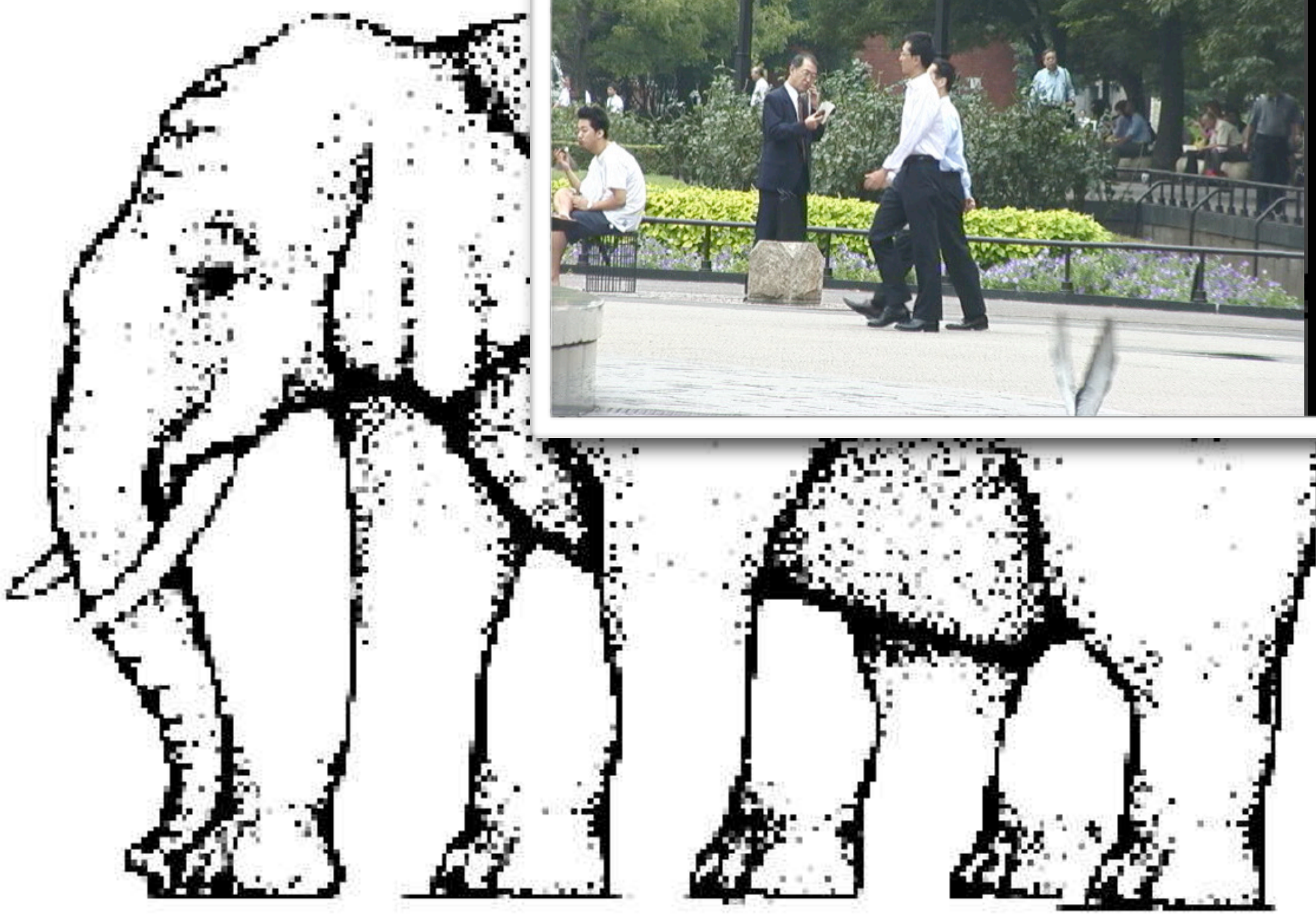
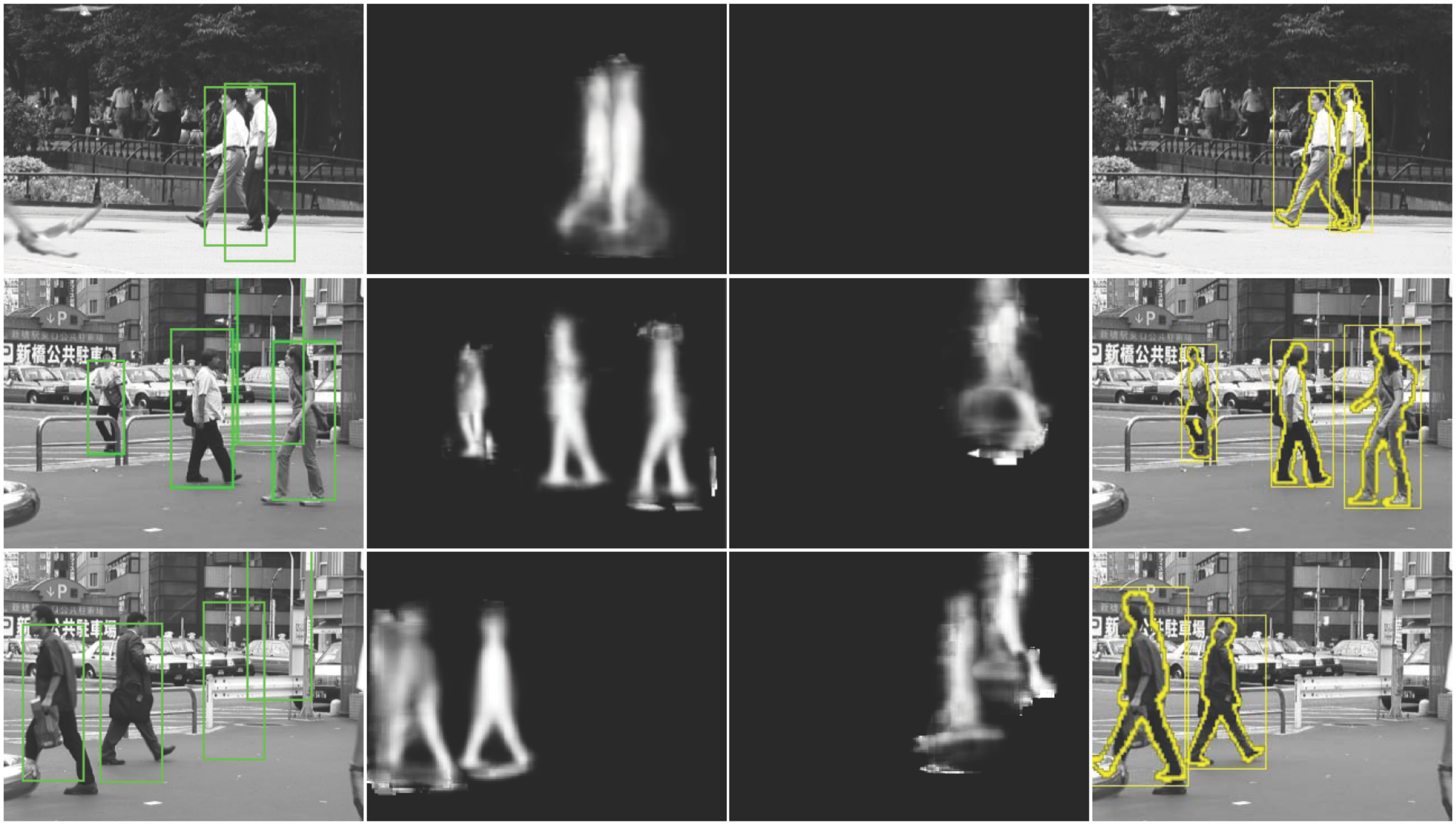


Global Silhouette Verification [Leibe@CVPR05]

- Initial hypotheses from local features
  - Implicit Shape Model
- Top-down segmentation for each hypothesis
- Verification using segmentations and global silhouettes
  - Chamfer verification
  - Shape constraints for articulated objects

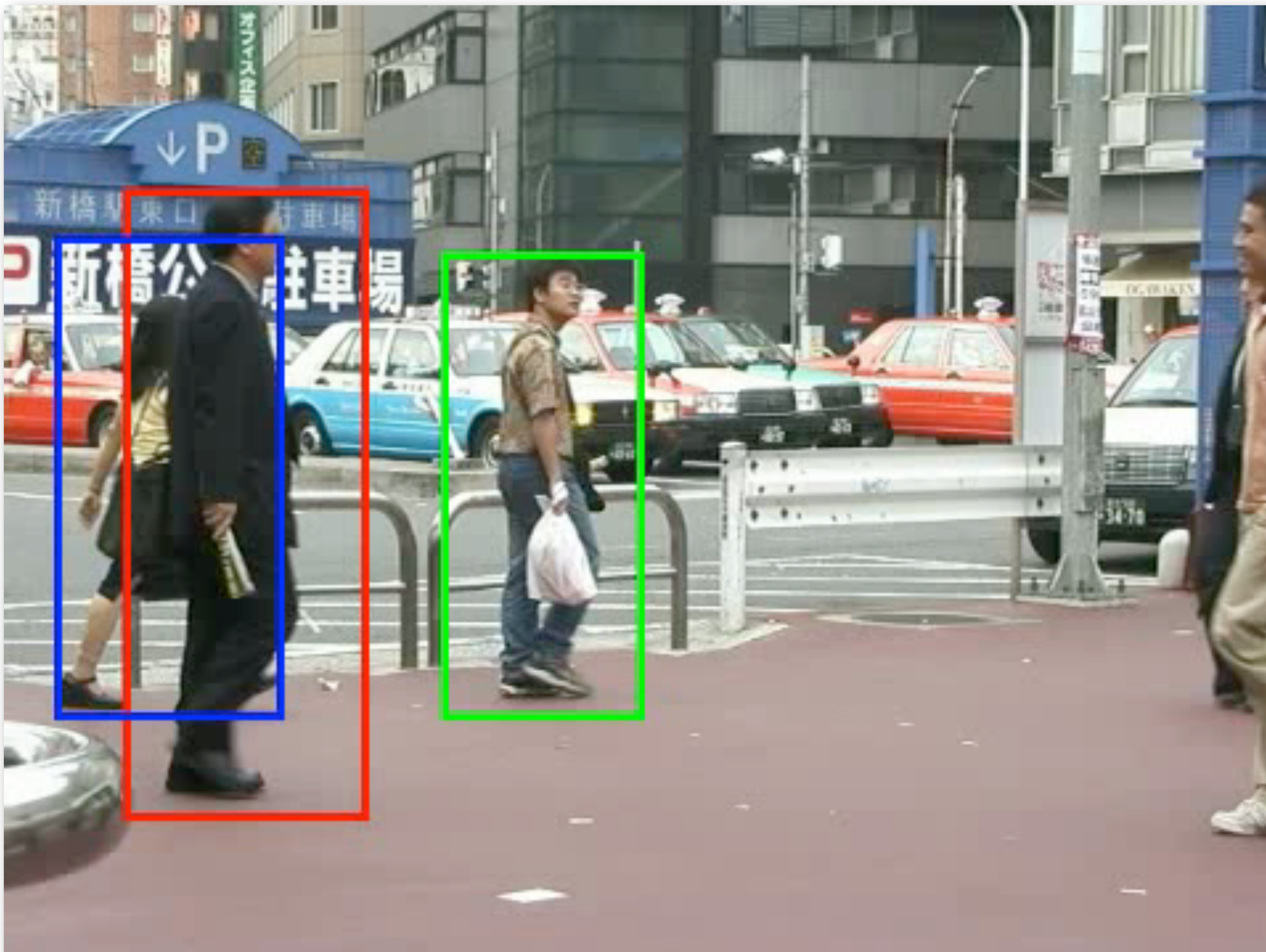
Effect of the Verification Stage



Detections at EER [Leibe@CVPR’05]

Single-frame detection – no temporal continuity used!

Tracking individual people...
[Seemann,Fritz@CVPR'07]

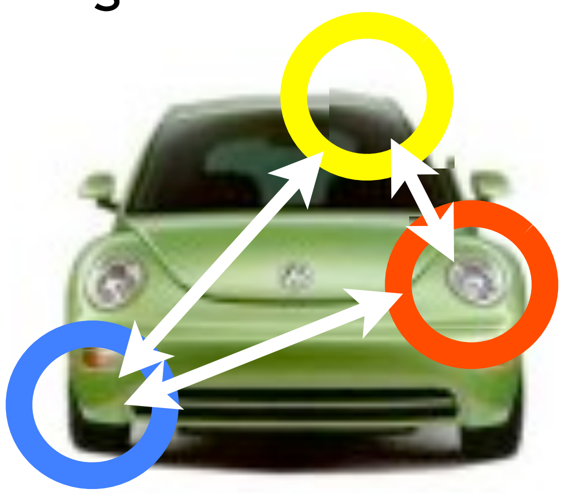


Combining Generative ISM detector with discriminant SVM

[Fritz'05]

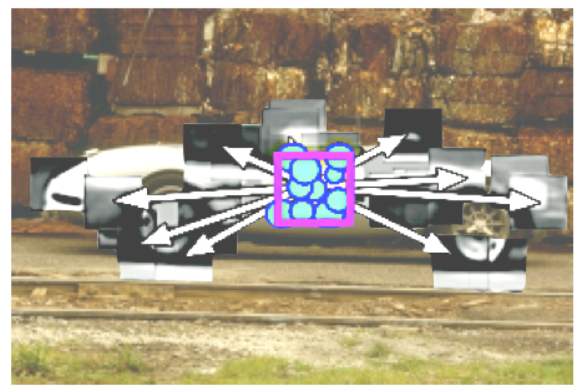
Modeling Paradigms: Generative vs. Discriminative

Burl’98
Weber’00 &Perona
Fergus’03



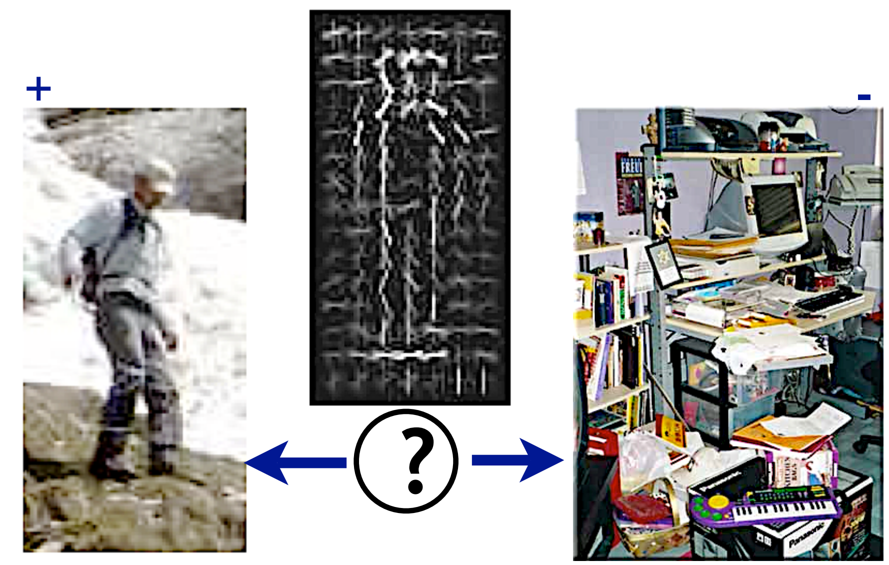
constellation model
(fully connected)

Leibe’04 & Schiele



implicit shape model
(star topology)

e.g. Dalal’05, Viola’01



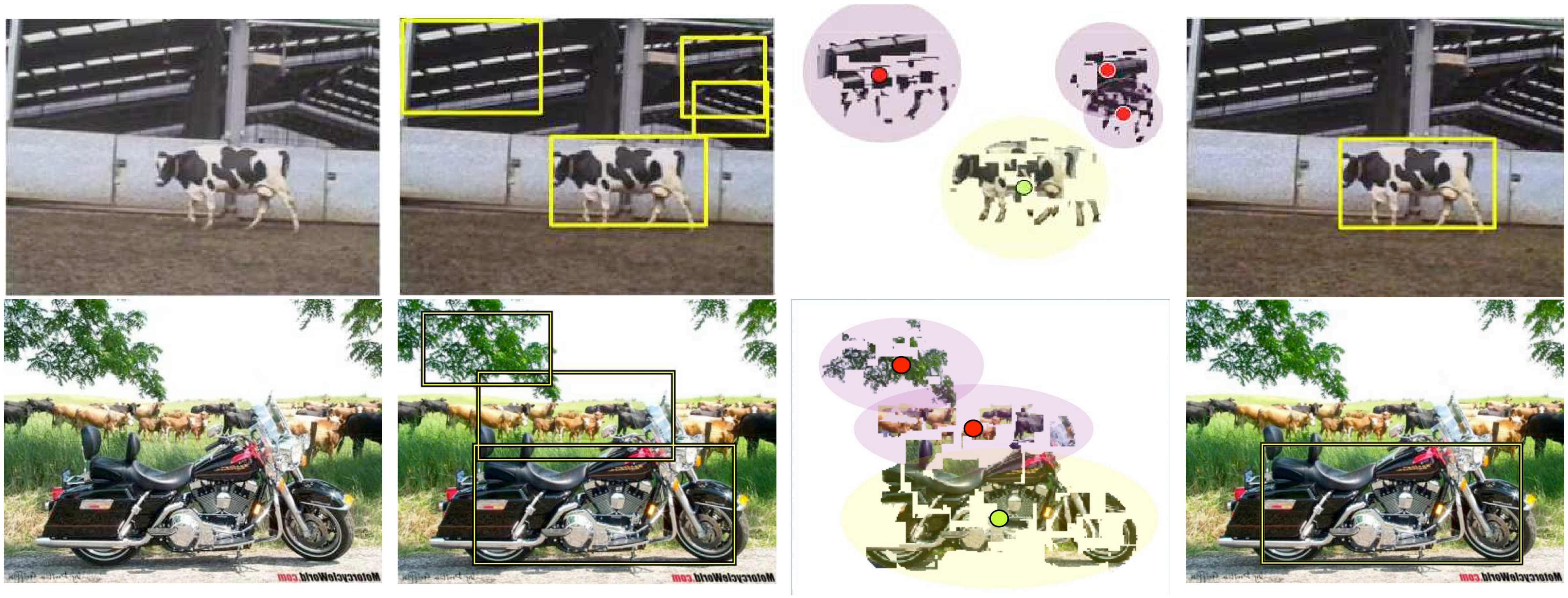
generic SVM,
Boosting

generative model	discriminative model

+ parallel, treat missing data
- often slow inference

+ focus on differences, precision
- often large training sets required

Generative/Discriminative Training [Fritz@ICCV05]



training ISM [Leibe04]

detect on train/validation (**generative**)

train classifier on true/false positive (**discriminative**)

improved detector (**hybrid**)

- Ideas:
  - good generalization of generative detector + precision of discriminant classifier
  - simplifying learning problem of classifier (localization, scale, background)
  - sampling structures that get confused

Local Kernel SVM

- kernel to match sets of local features [Wallraven03,Caputo04]

$$K(X,Y) = \frac{1}{k} \max_{\Phi,\Psi} \sum_{j=1}^{k} K_l \left((\vec{x}_{\Phi(j)}, \lambda_{x,\Phi(j)}), (\vec{y}_{\Psi(j)}, \lambda_{y,\Psi(j)}) \right)$$

maximum over permutations

local feature similarity kernel

patch

position

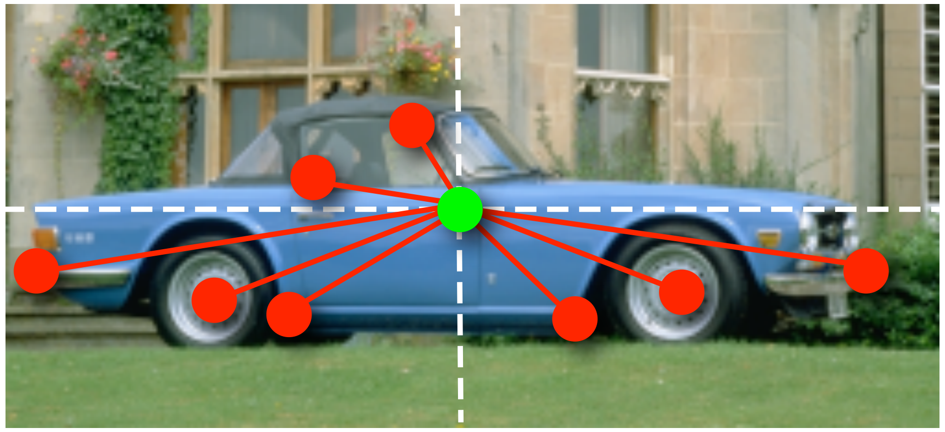
- greedy approximation of maximum/matching
- non-mercer kernel
- but in setting used in practice, kernel matrix is positive definite [Boughorbel04]

Local Kernel SVM (2)

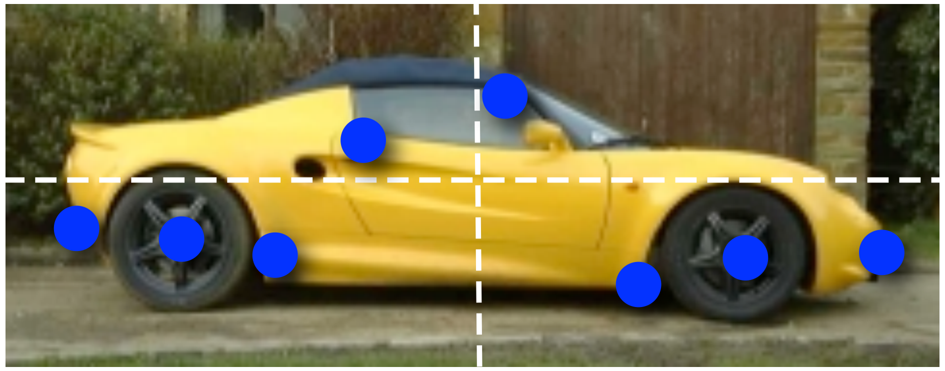
- uses local features similarity kernel:

$$K((\vec{x},\lambda_x),(\vec{y},\lambda_y)) = \underbrace{\exp\left(-\gamma(1- <\vec{x},\vec{y}>)\right)}_{appearance\ similarity}\ \underbrace{\exp\left(-\frac{(\lambda_x-\lambda_y)^2}{2\sigma^2}\right)}_{position\ constraint}$$

- we evaluated directly on codebook representation
  - across instance learning
- strong shape model
- constraints extends also to relative scale



X



Y

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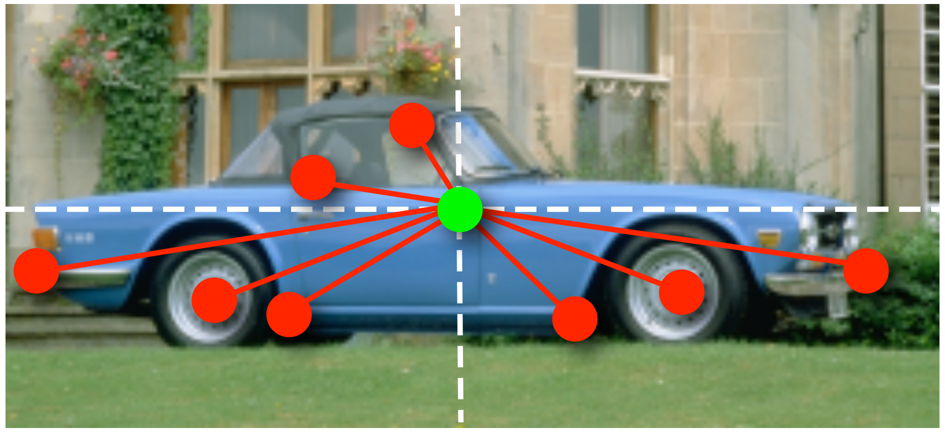

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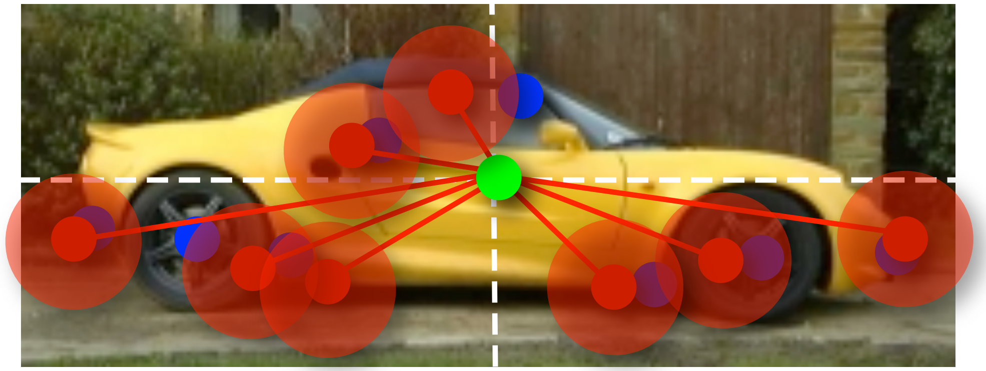
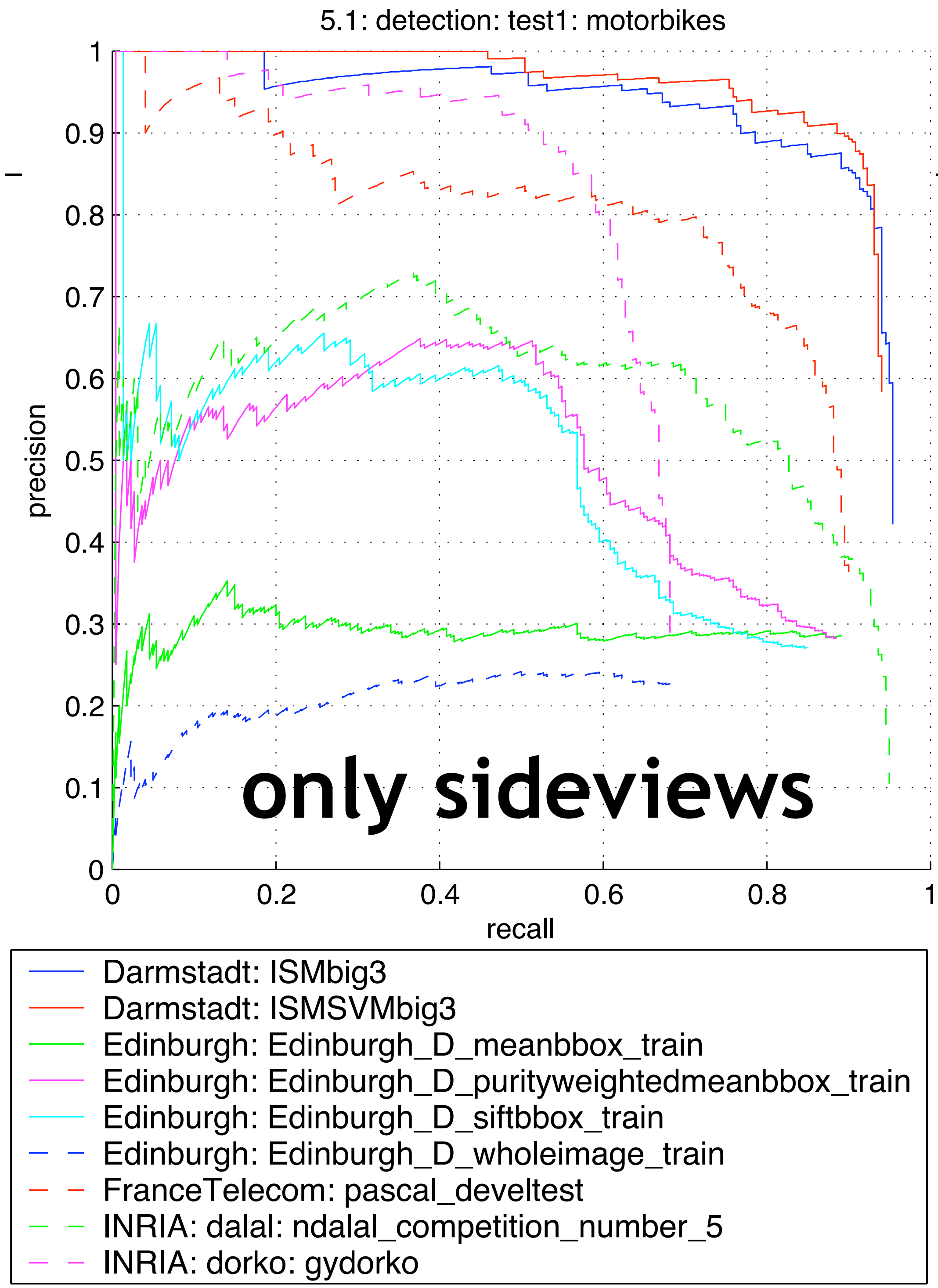
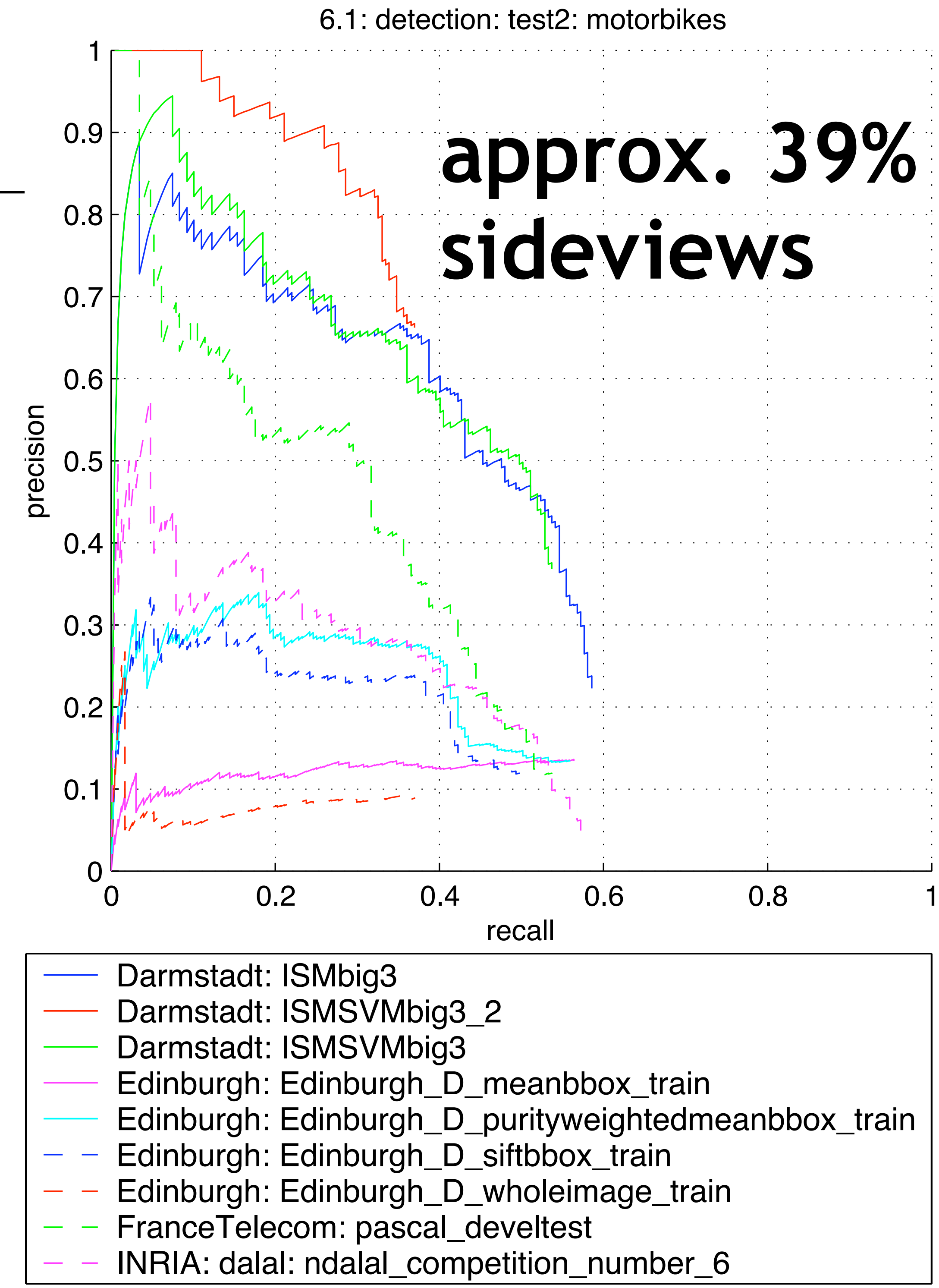


Y

Results of Motorbike Detector

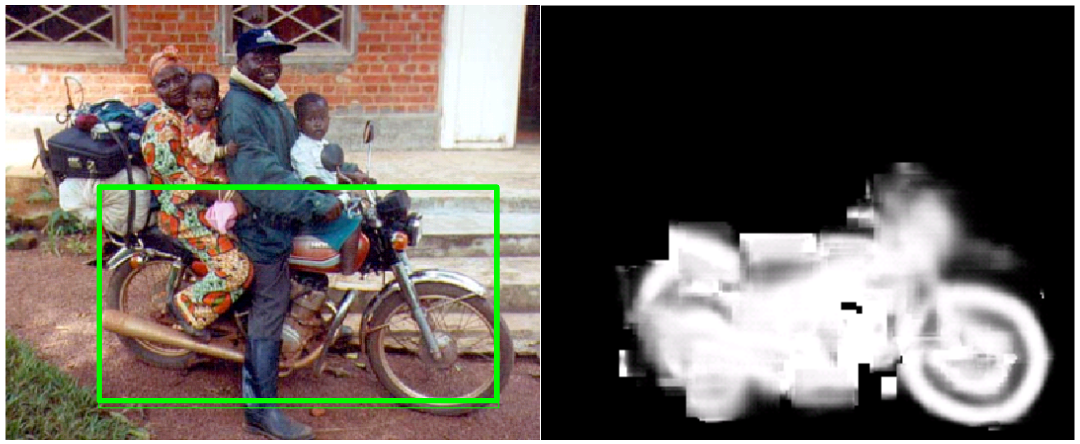


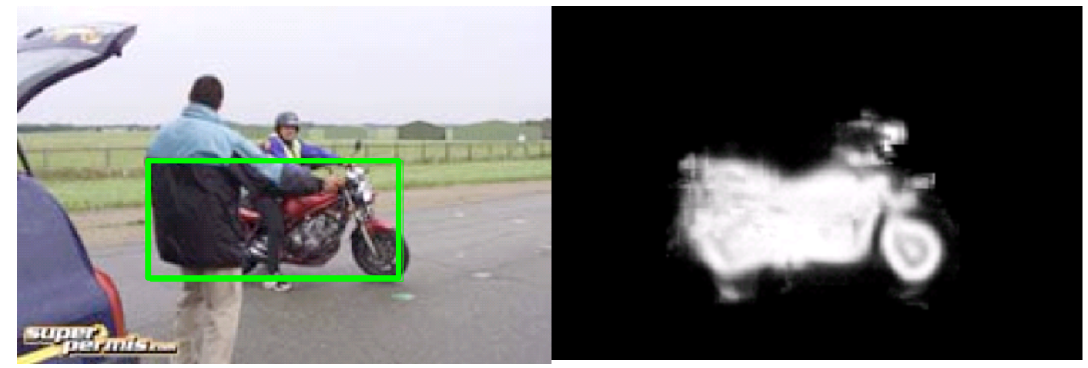


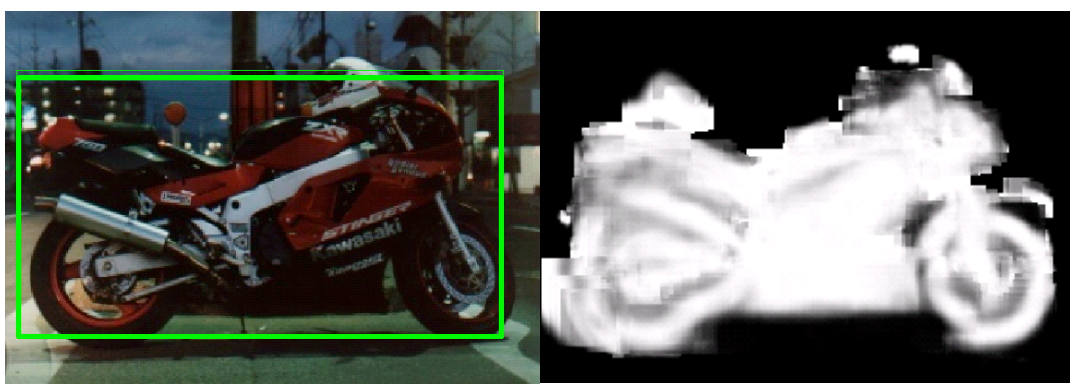
- SVM adds desired precision to ISM
- high precision and recall for sideviews

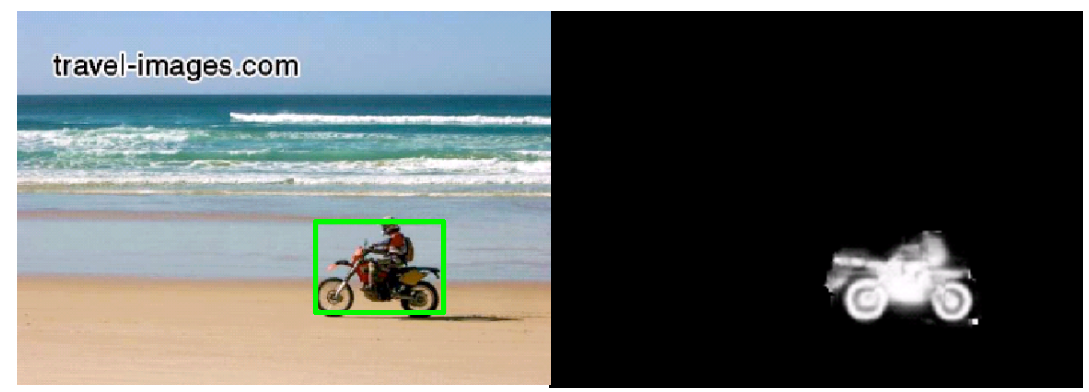
Motorbike Detection/Segmentation on Pascal05

test 2

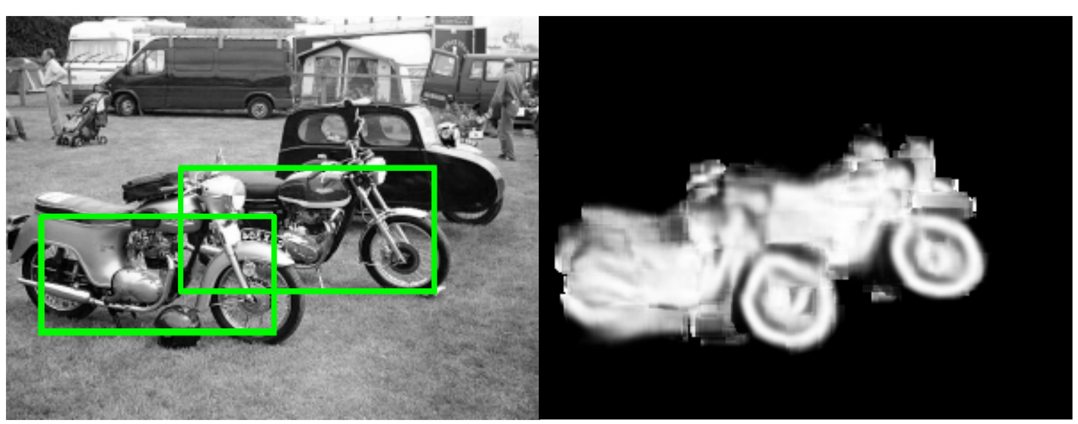




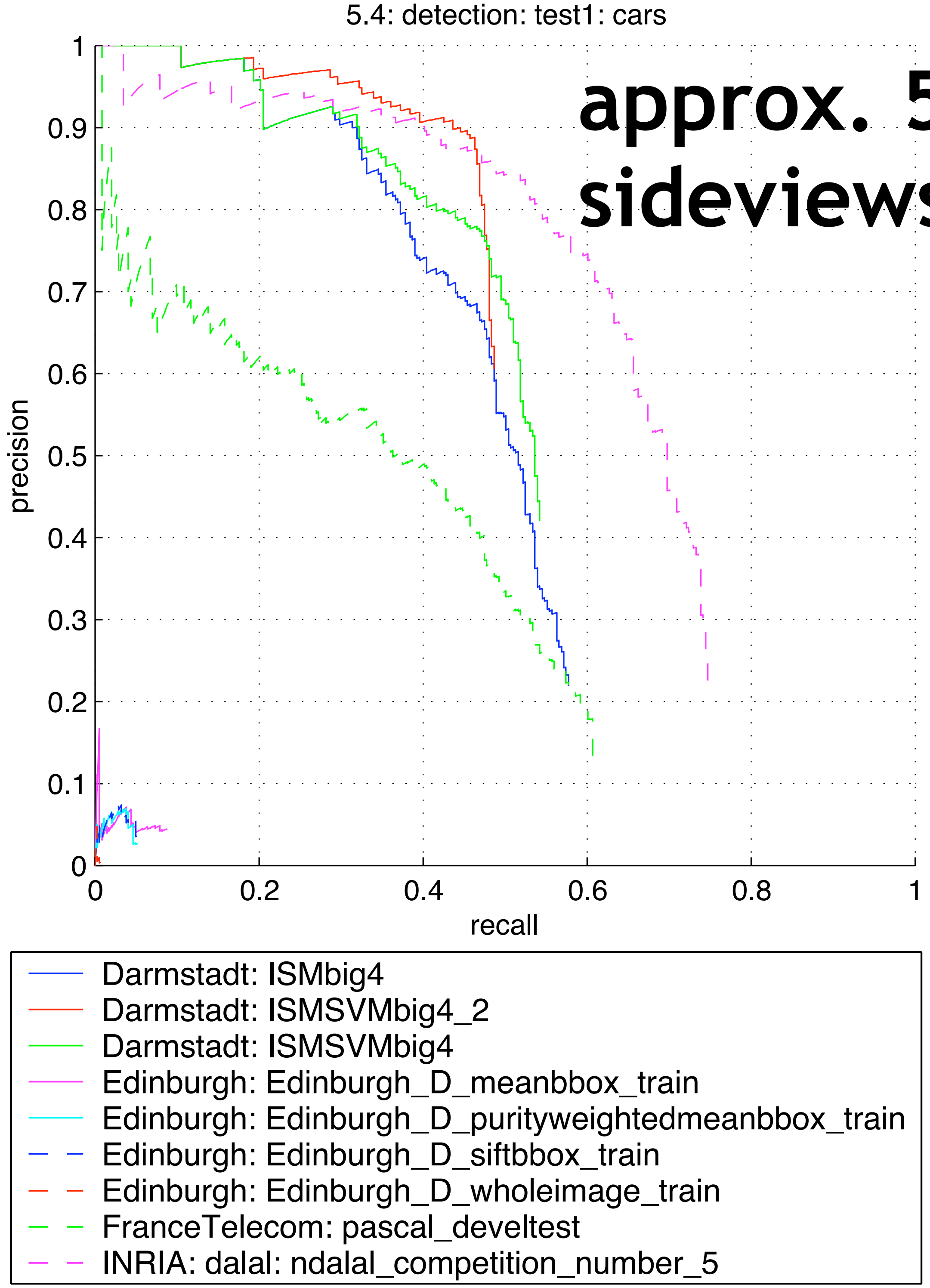


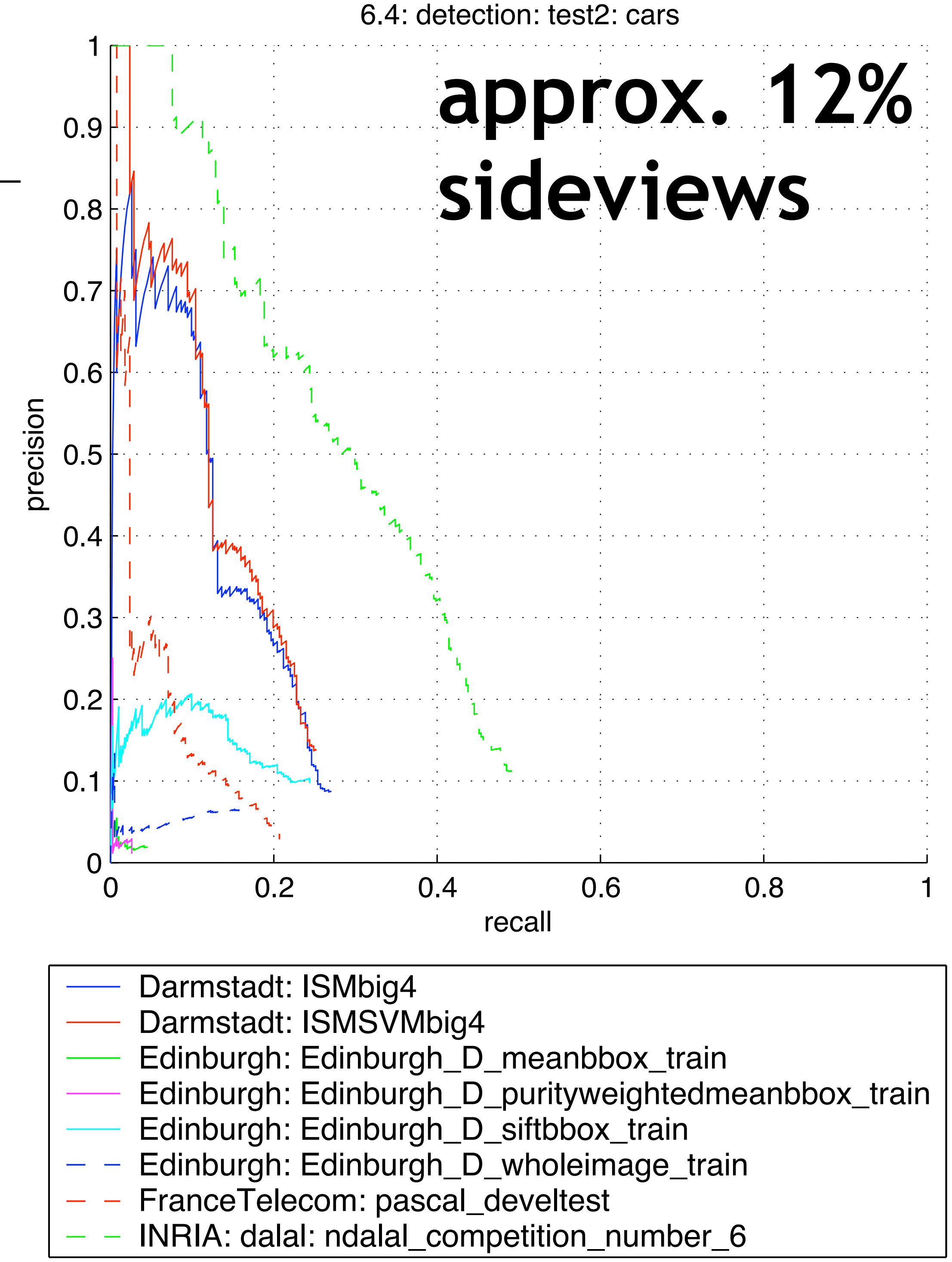


test 1



Results on Car Detection





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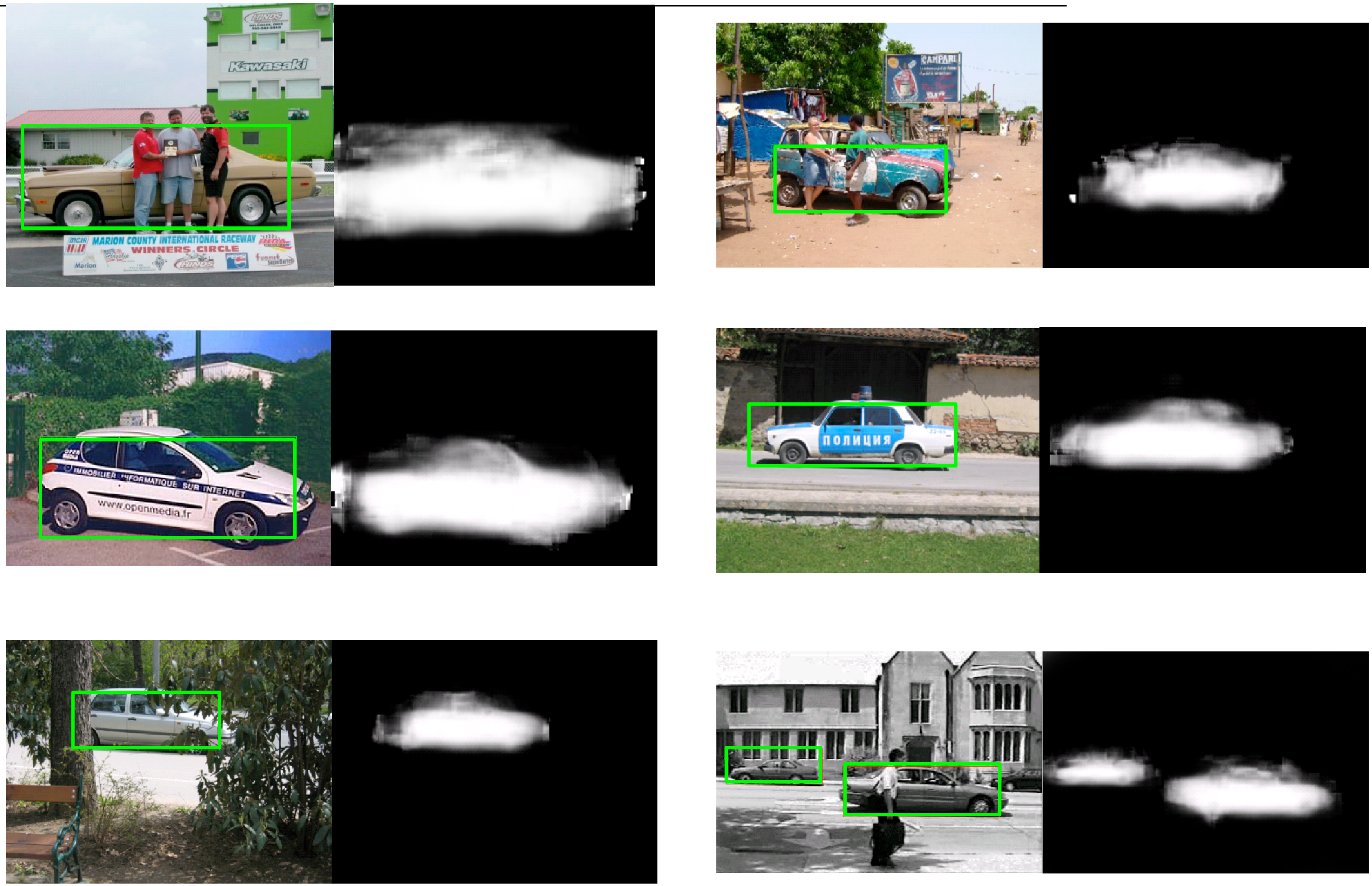
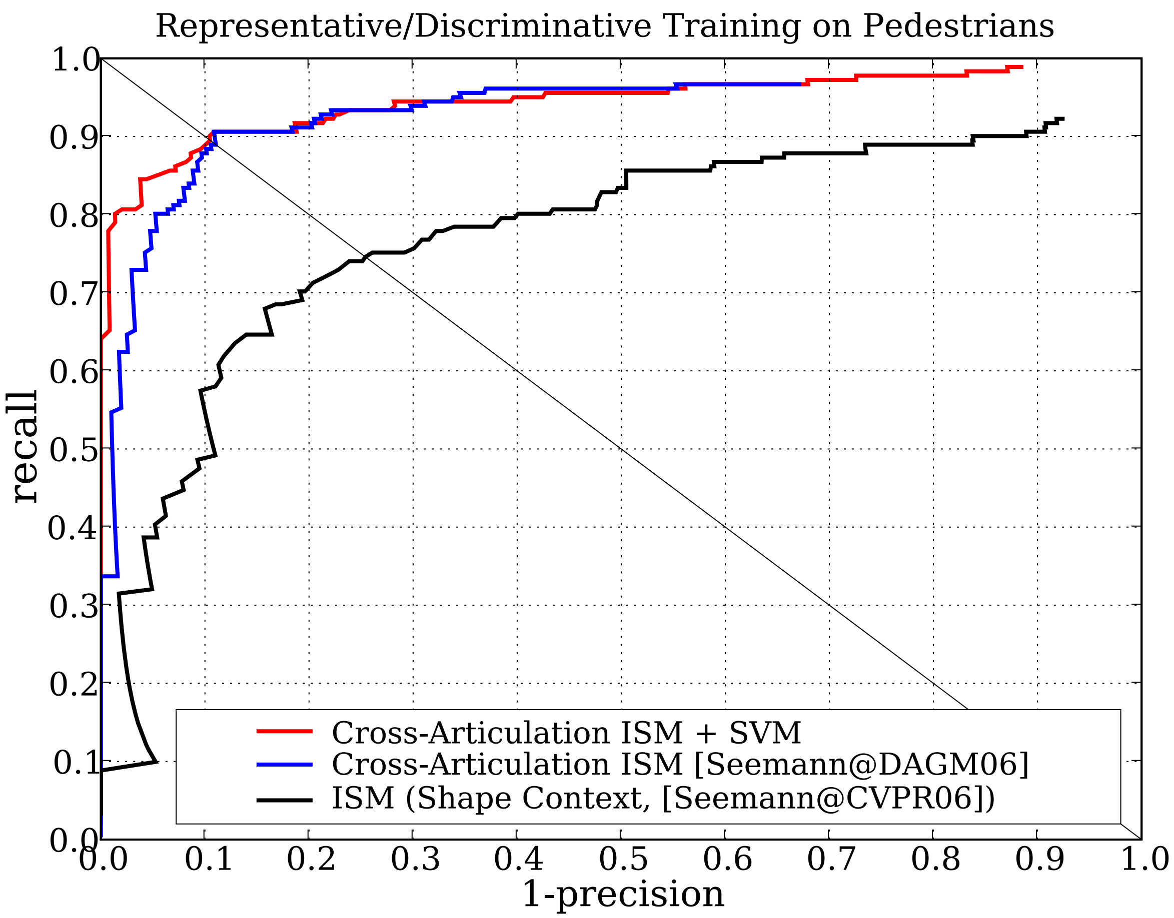
Car Detection/Segmentation on Pascal05

test 2

test 1



Improving Pedestrian Detection by Generative/ Discriminant Training



- single shot/no groundplane
- improved precision
- first false positives at 65% recall