Diagnosing Error in Object Detectors

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Object detection is a collection of problems

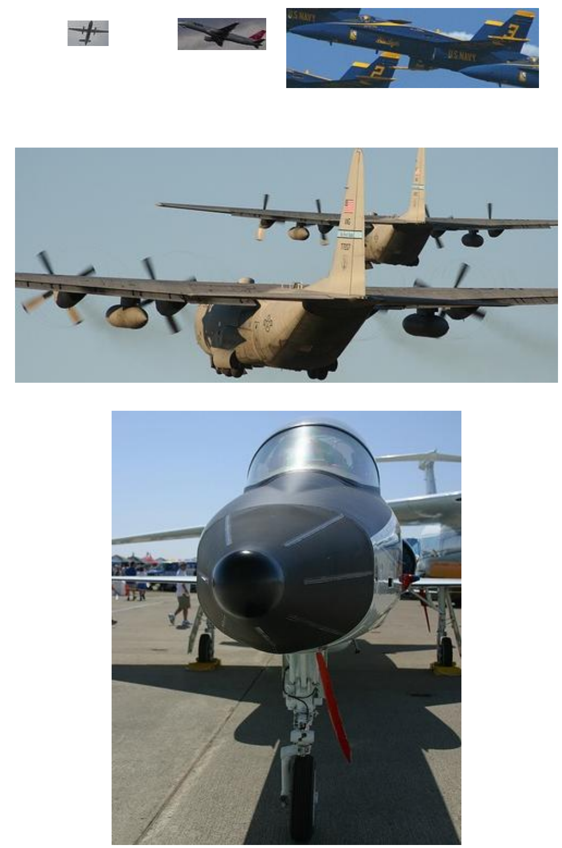
Intra-class Variation for “Airplane”

Occlusion

Shape

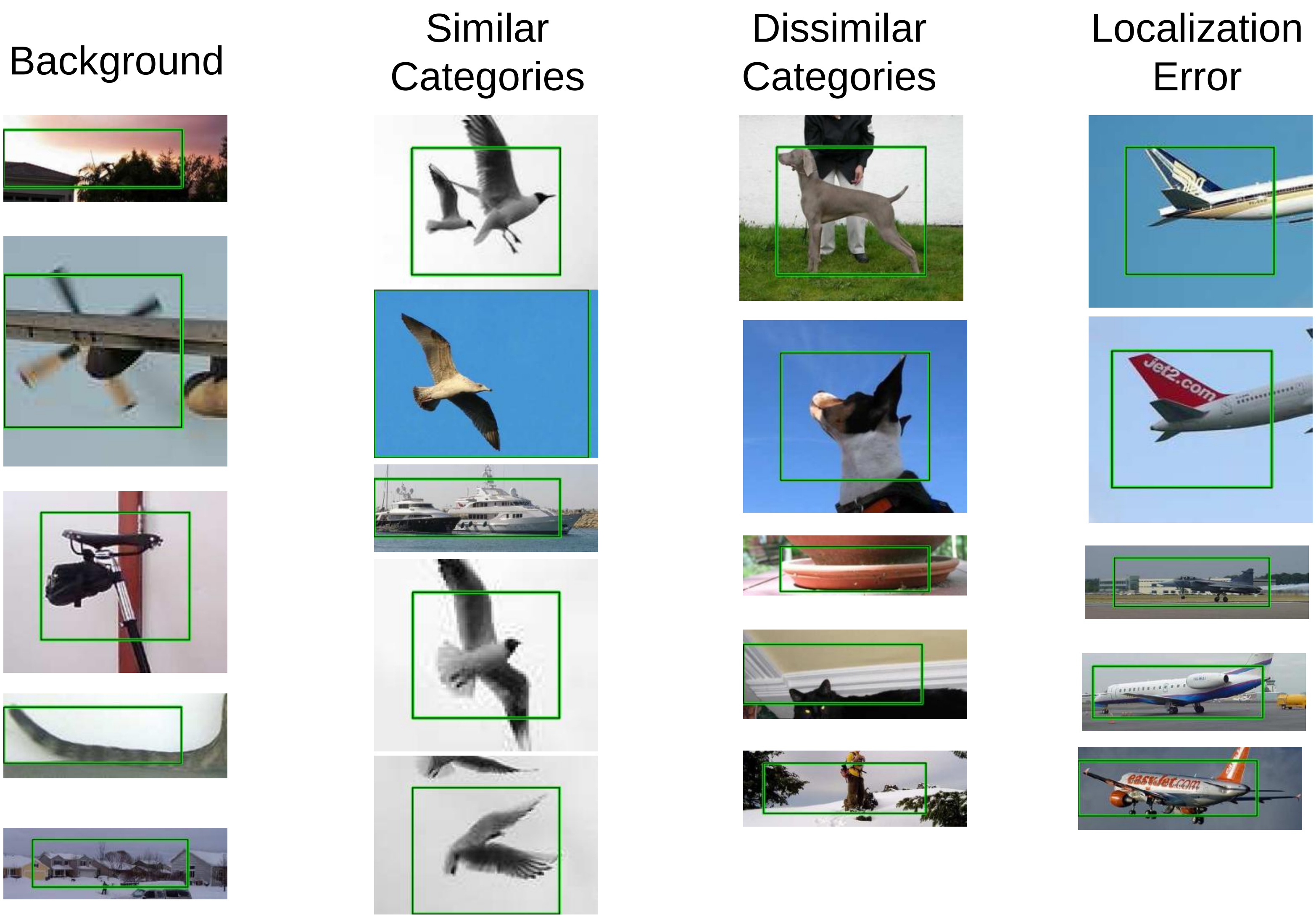
Viewpoint

Distance



Object detection is a collection of problems

Confusing Distractors for “Airplane”

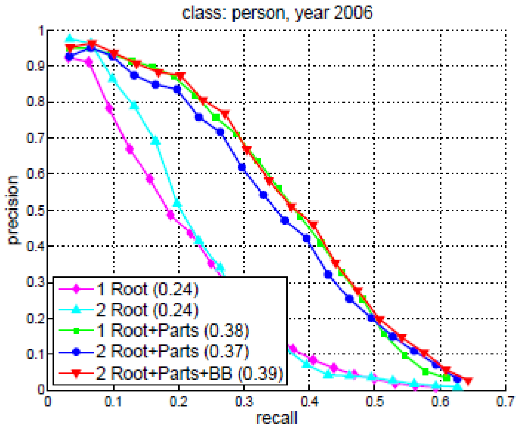


How to evaluate object detectors?

- Average Precision (AP)
  - Good summary statistic for quick comparison
  - Not a good driver of research

	aero	bike	bird	boat	bottle	bus
a) base	.290	.546	.006	.134	.262	.394
b) BB	.287	.551	.006	.145	.265	.397
c) context	.328	.568	.025	.168	.285	.397

Typical evaluation through comparison of AP numbers



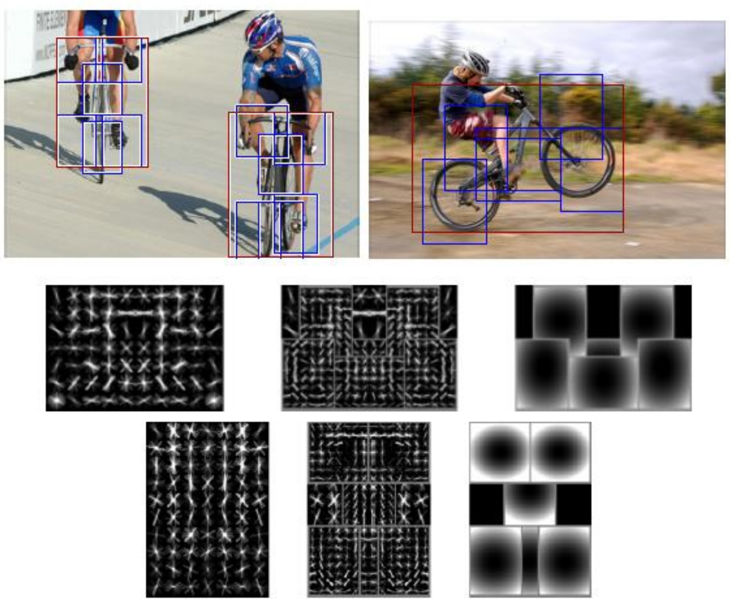
- We propose tools to evaluate
  - where detectors fail
  - potential impact of particular improvements

figs from Felzenszwalb et al. 2010

Detectors Analyzed as Examples on VOC 2007

Deformable Parts Model (DPM)

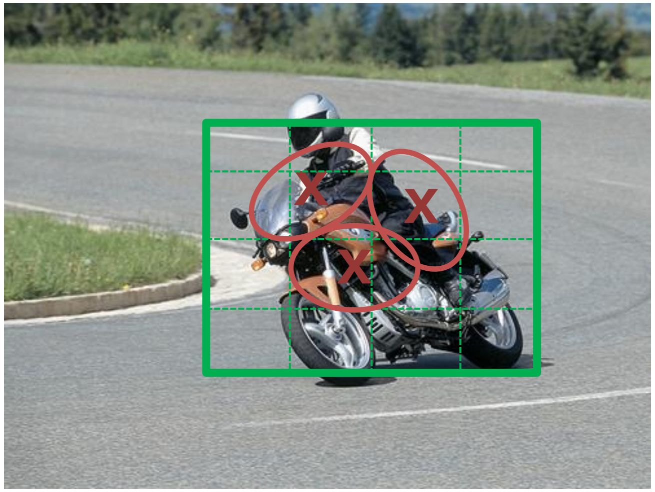
- Sliding window
- Mixture of HOG templates with latent HOG parts



Felzenszwalb et al. 2010 (v4)

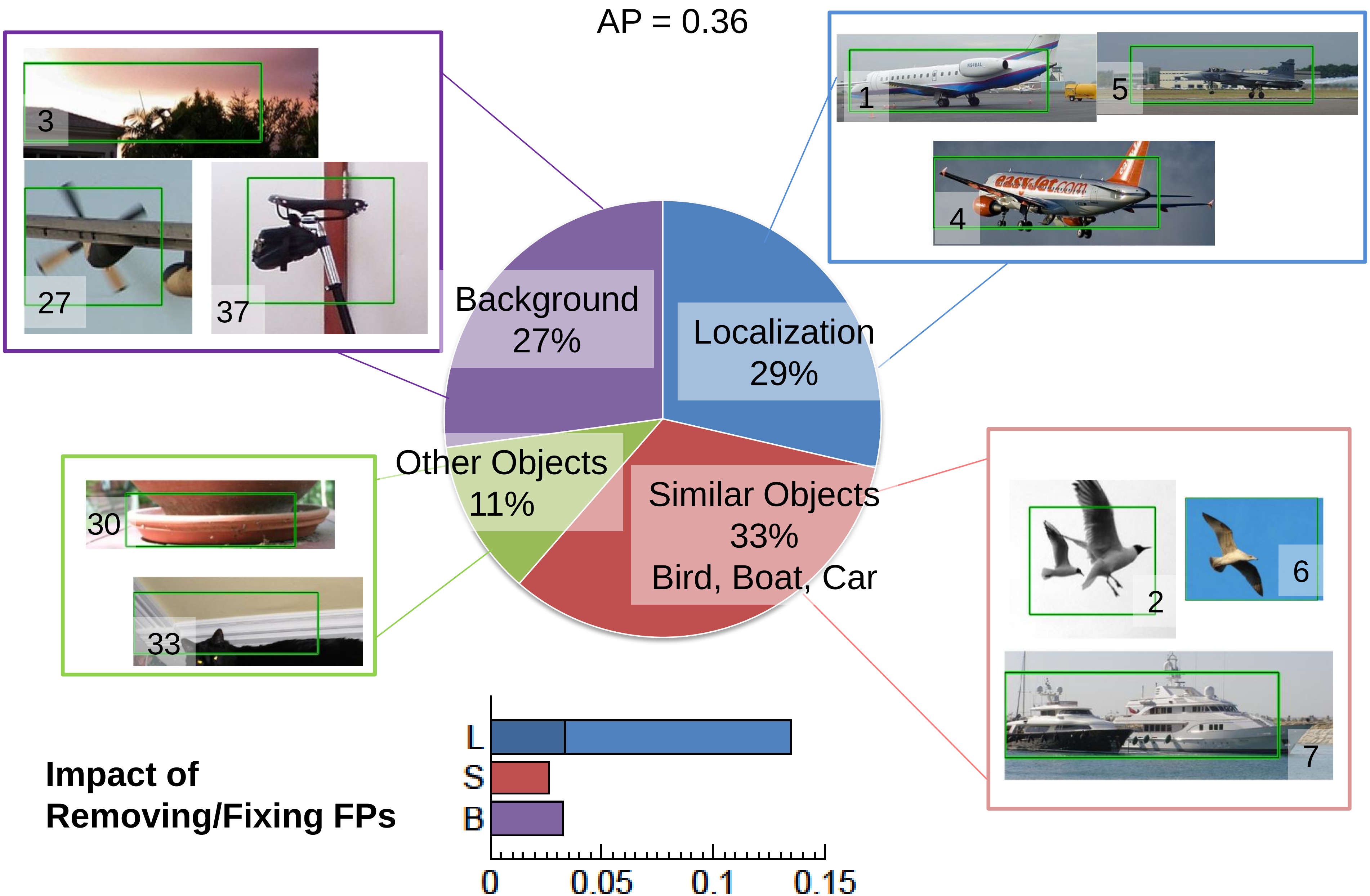
Multiple Kernel Learning (MKL)

- Jumping window
- Various spatial pyramid bag of words features combined with MKL

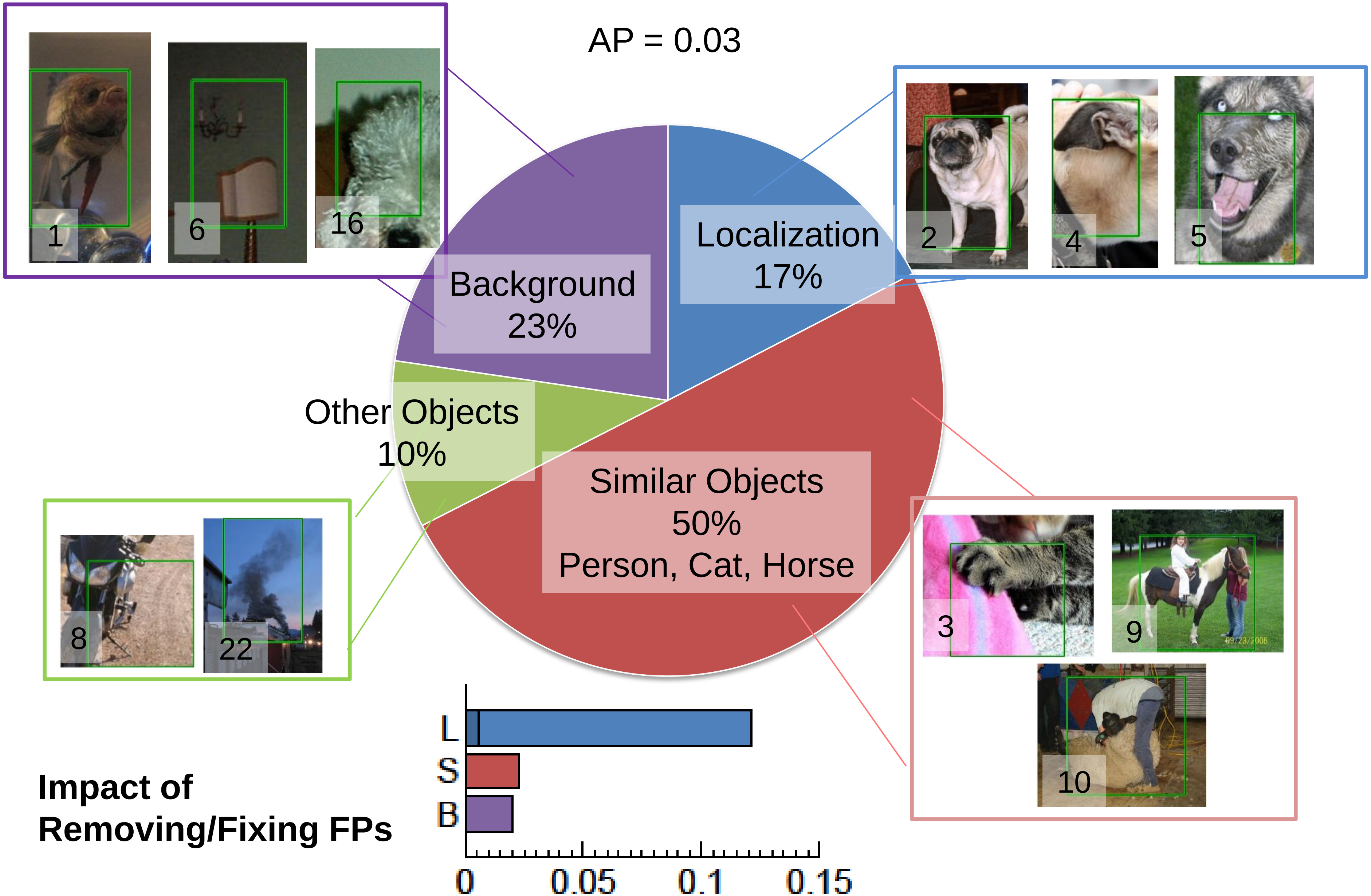


Vedaldi et al. 2009

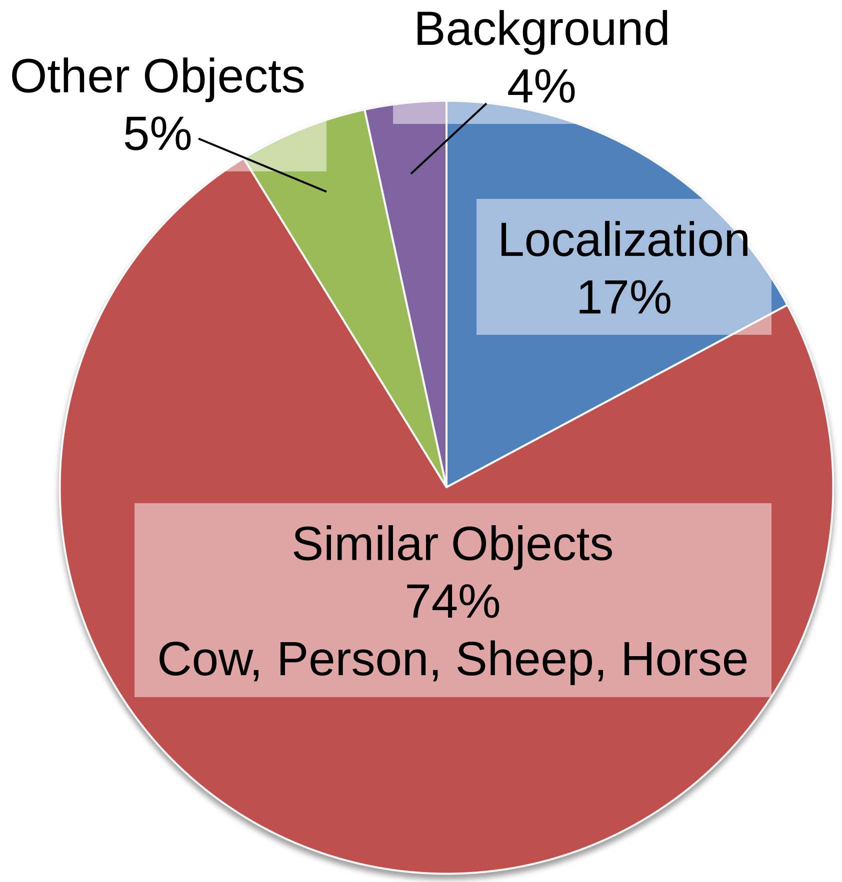
Top false positives: Airplane (DPM)



Top false positives: Dog (DPM)

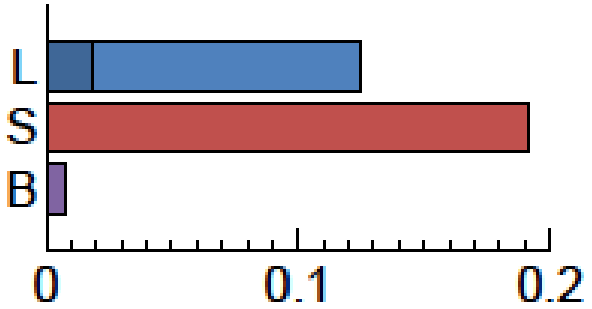


Top false positives: Dog (MKL)

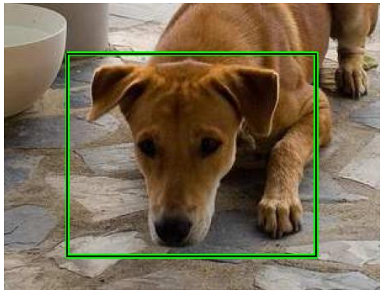


AP = 0.17

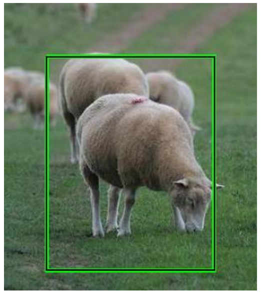
Impact of Removing/Fixing FPs



Top 5 FP

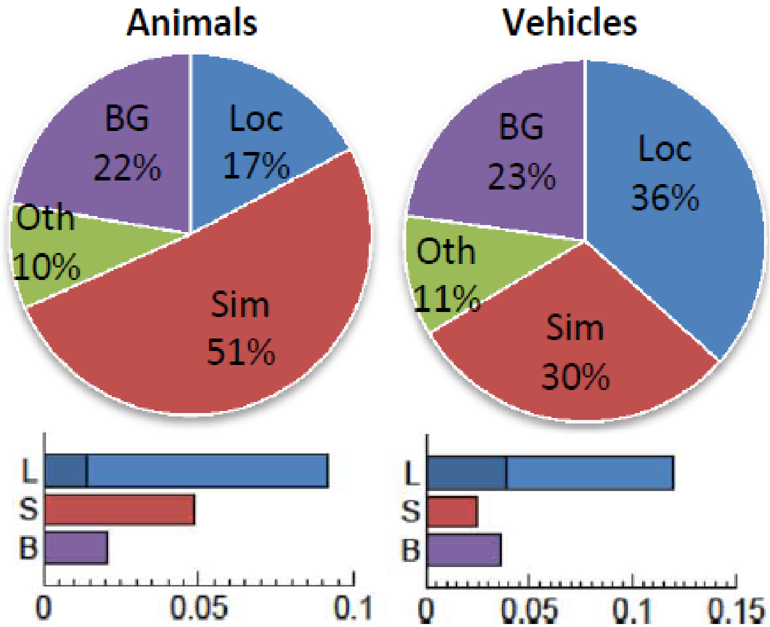




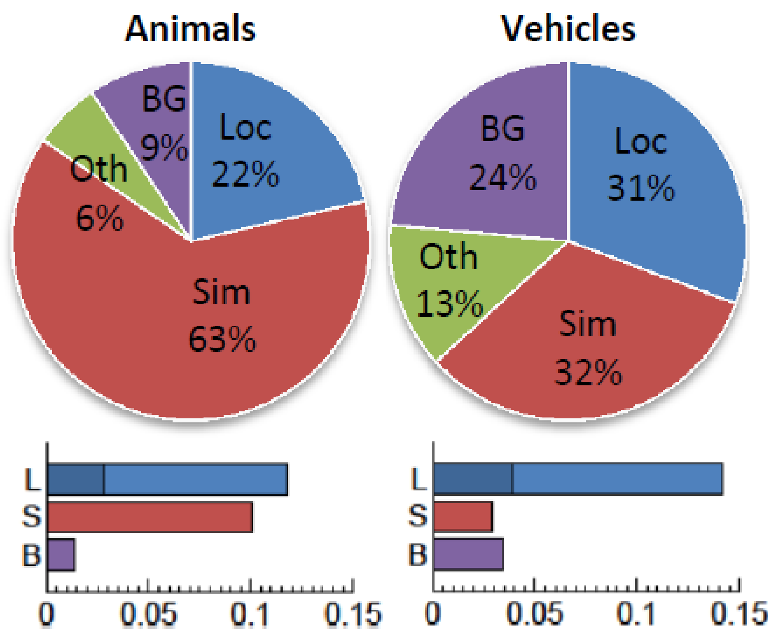


Summary of False Positive Analysis

DPM v4
(FGMR 2010)



MKL
(Vedaldi et al. 2009)



Analysis of object characteristics

Additional annotations for seven categories: occlusion level, parts visible, sides visible

Level of occlusion: 2 (moderate)
Parts visible: bike body, handlebars, wheel
Parts not visible: seat
View: side visible (front, top, etc., not visible)
Area: 3233 pixels
Aspect Ratio (w/h): 1.24

Occlusion Level

Normalized Average Precision

- Average precision is sensitive to number of positive examples

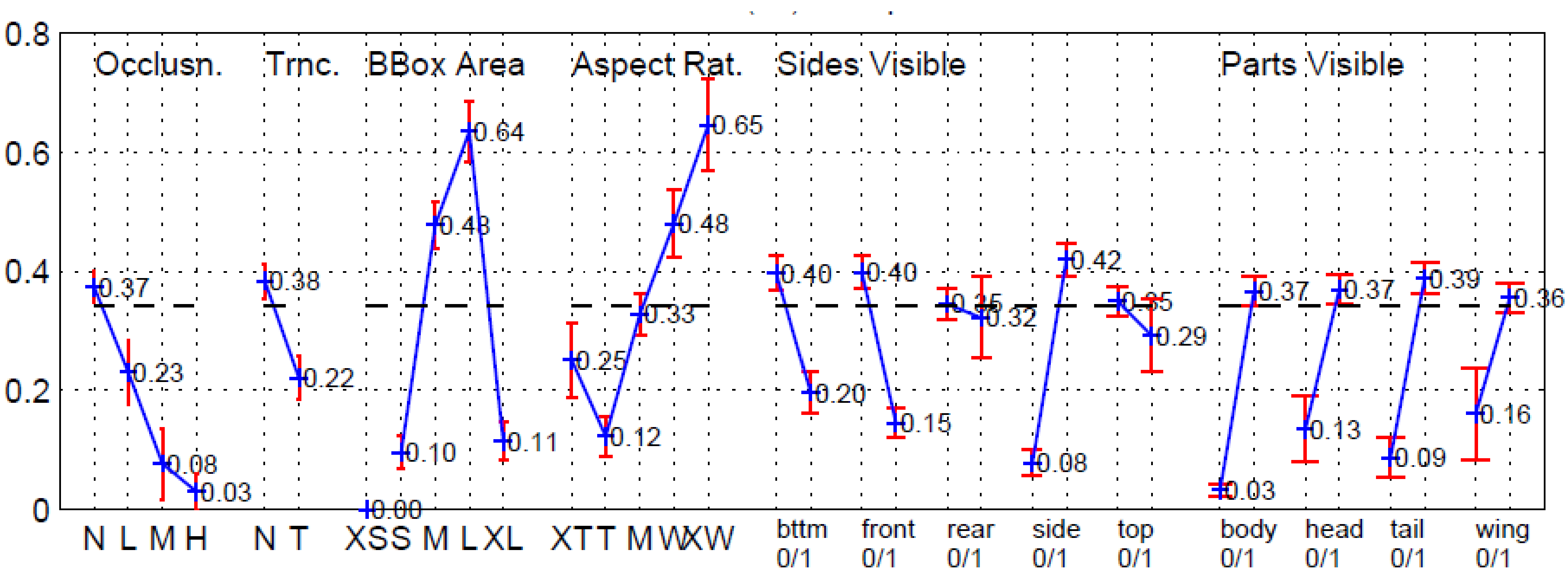
$$\text{Precision} = \frac{\text{TruePositives}}{\text{TruePositives} + \text{FalsePositives}}$$

$$\text{TruePositives} = \text{Recall} * N_j$$

Number of object examples in subset j

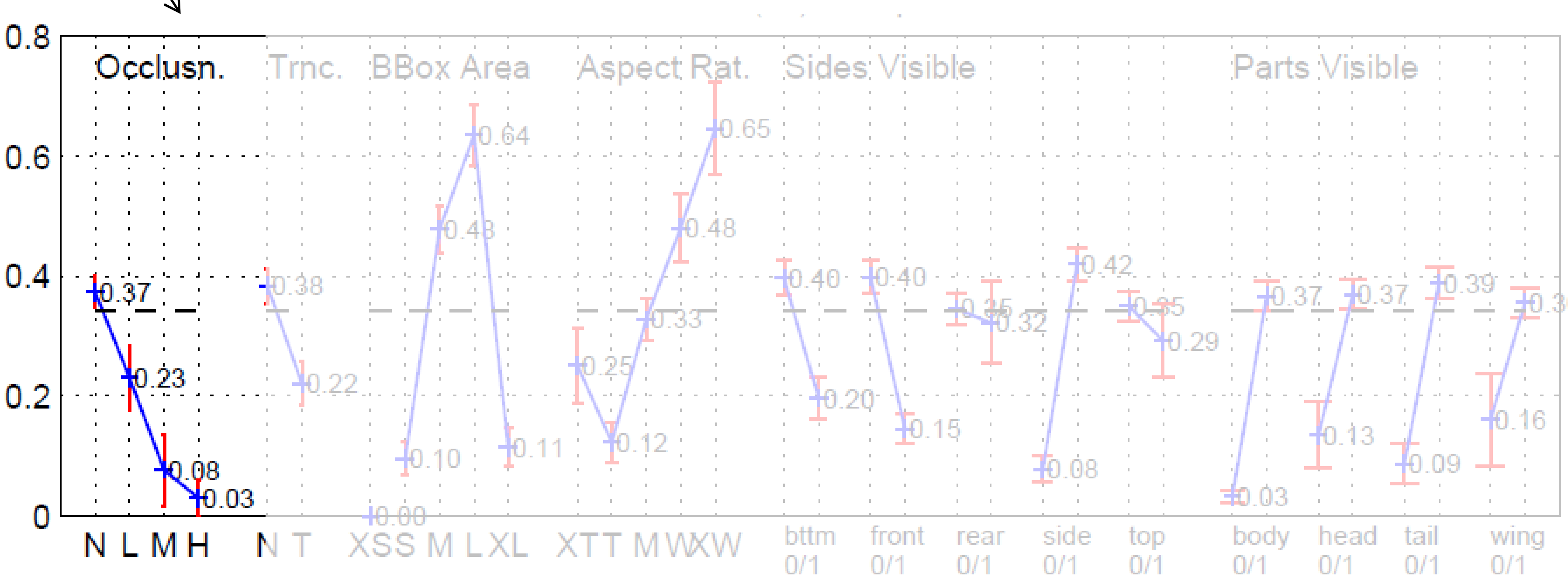
- Normalized average precision: replace variable N_j with fixed N

Object characteristics: Aeroplane



Object characteristics: Aeroplane

Occlusion: poor robustness to occlusion, but little impact on overall performance

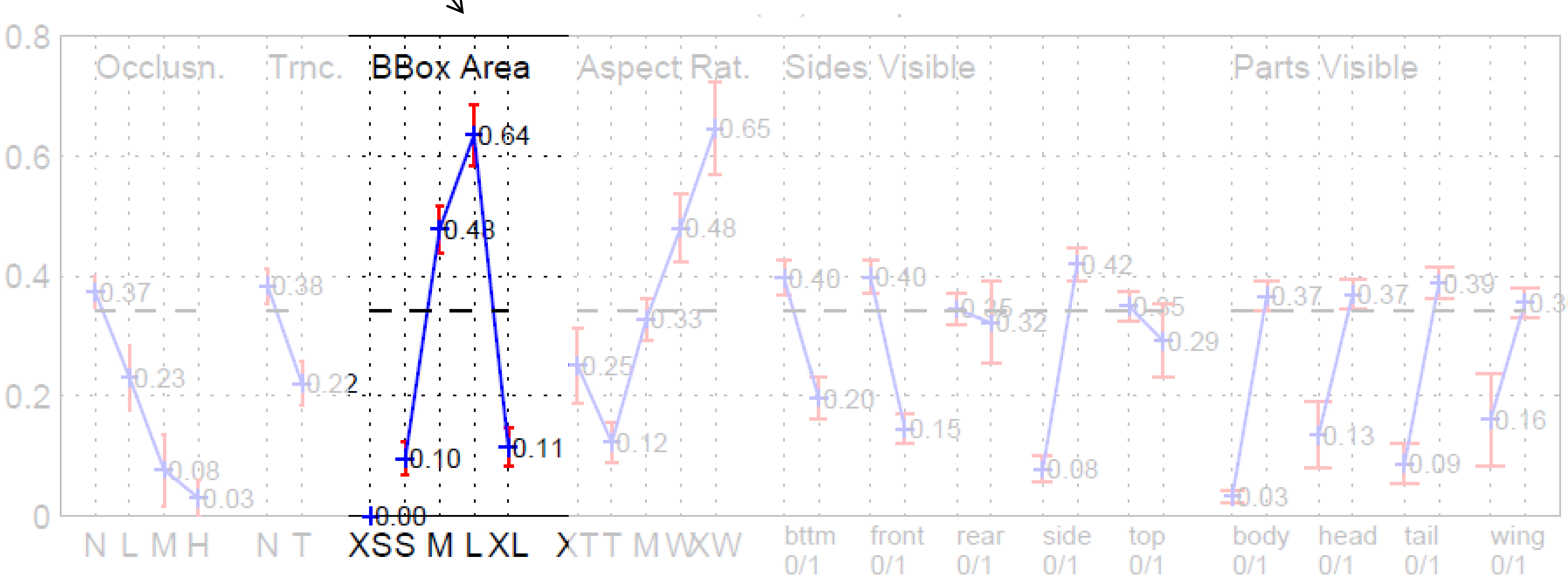


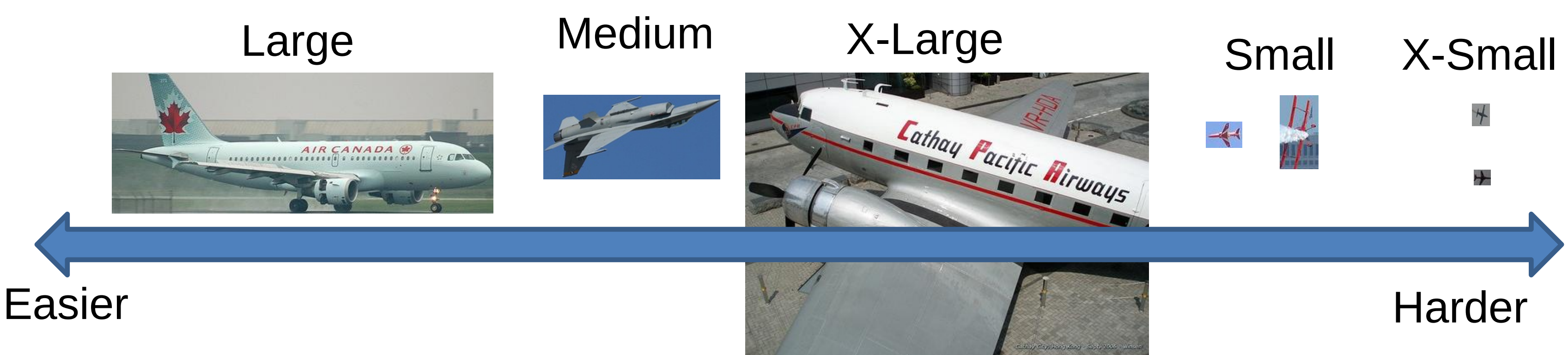
Easier (None)

Harder (Heavy)

Object characteristics: Aeroplane

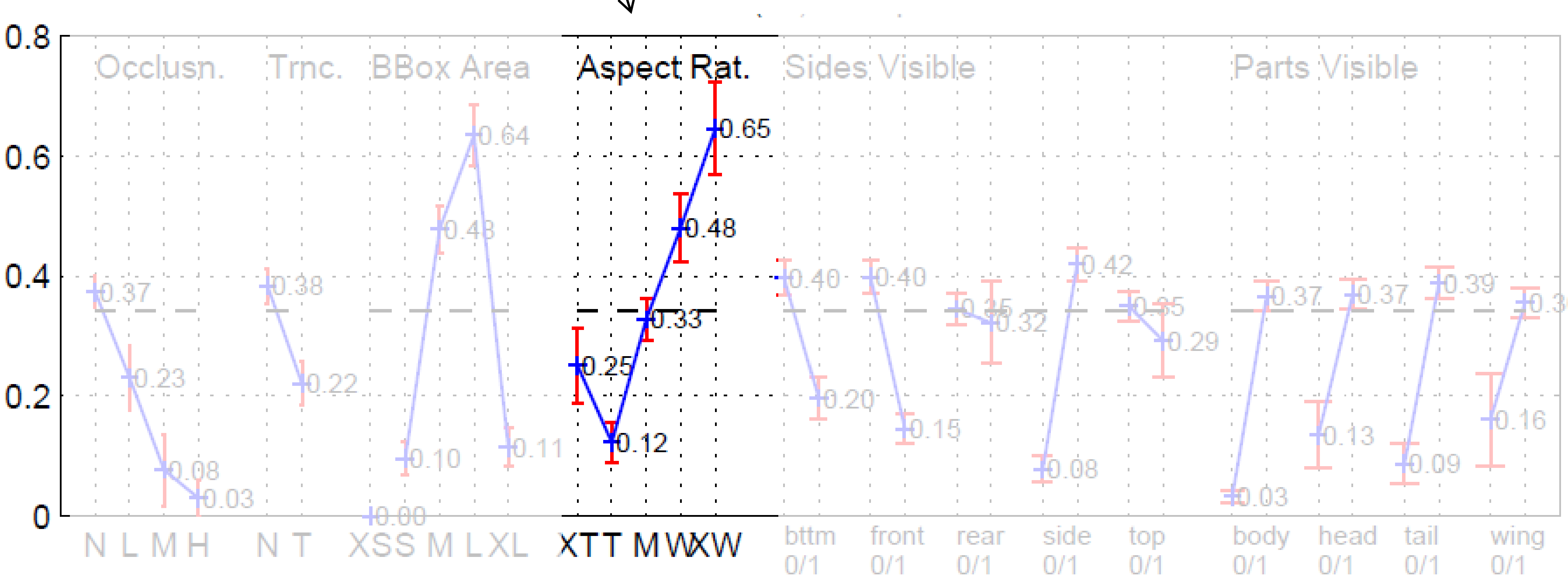
Size: strong preference for average to above average sized airplanes





Object characteristics: Aeroplane

Aspect Ratio: 2-3x better at detecting wide (side) views than tall views



X-Wide

Wide

Medium

X-Tall

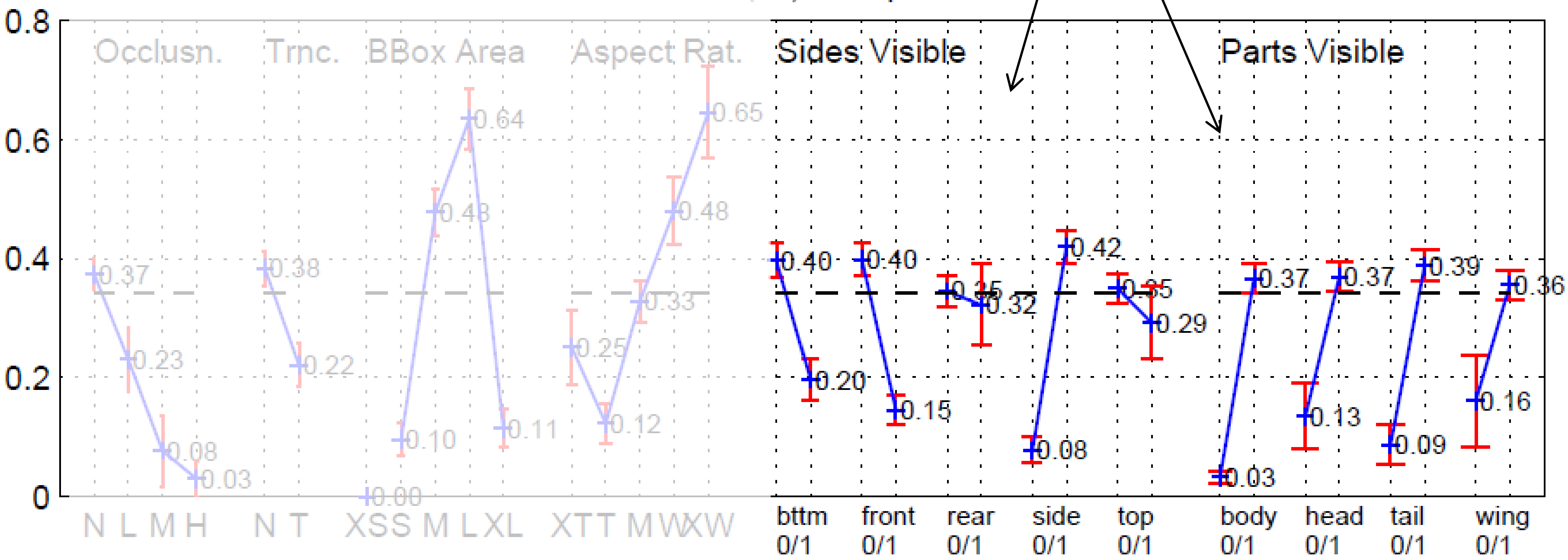
Tall

Easier (Wide)

Harder (Tall)

Object characteristics: Aeroplane

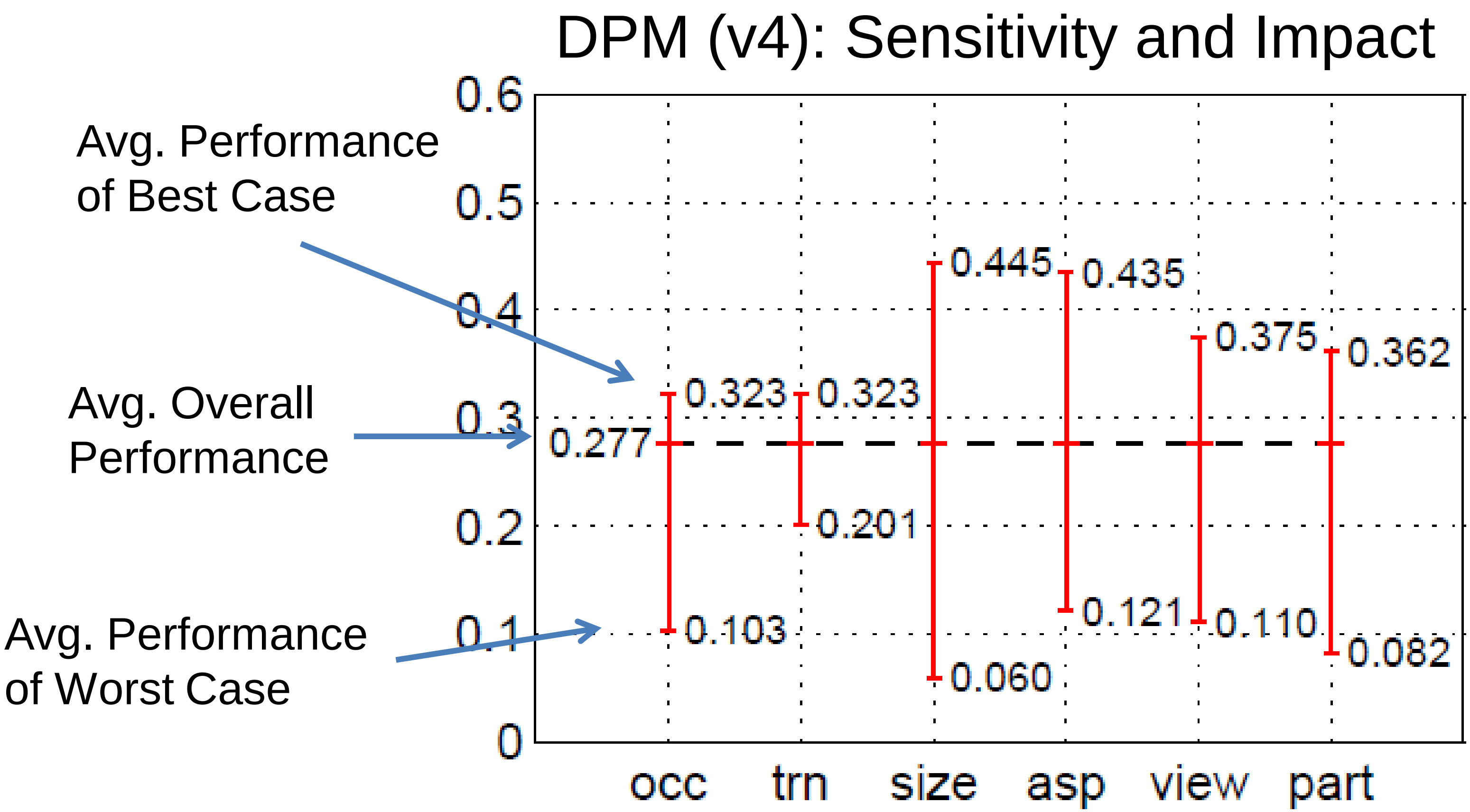
Sides/Parts: best performance = direct side view with all parts visible



Easier (Side)

Harder (Non-Side)

Summarizing Detector Performance



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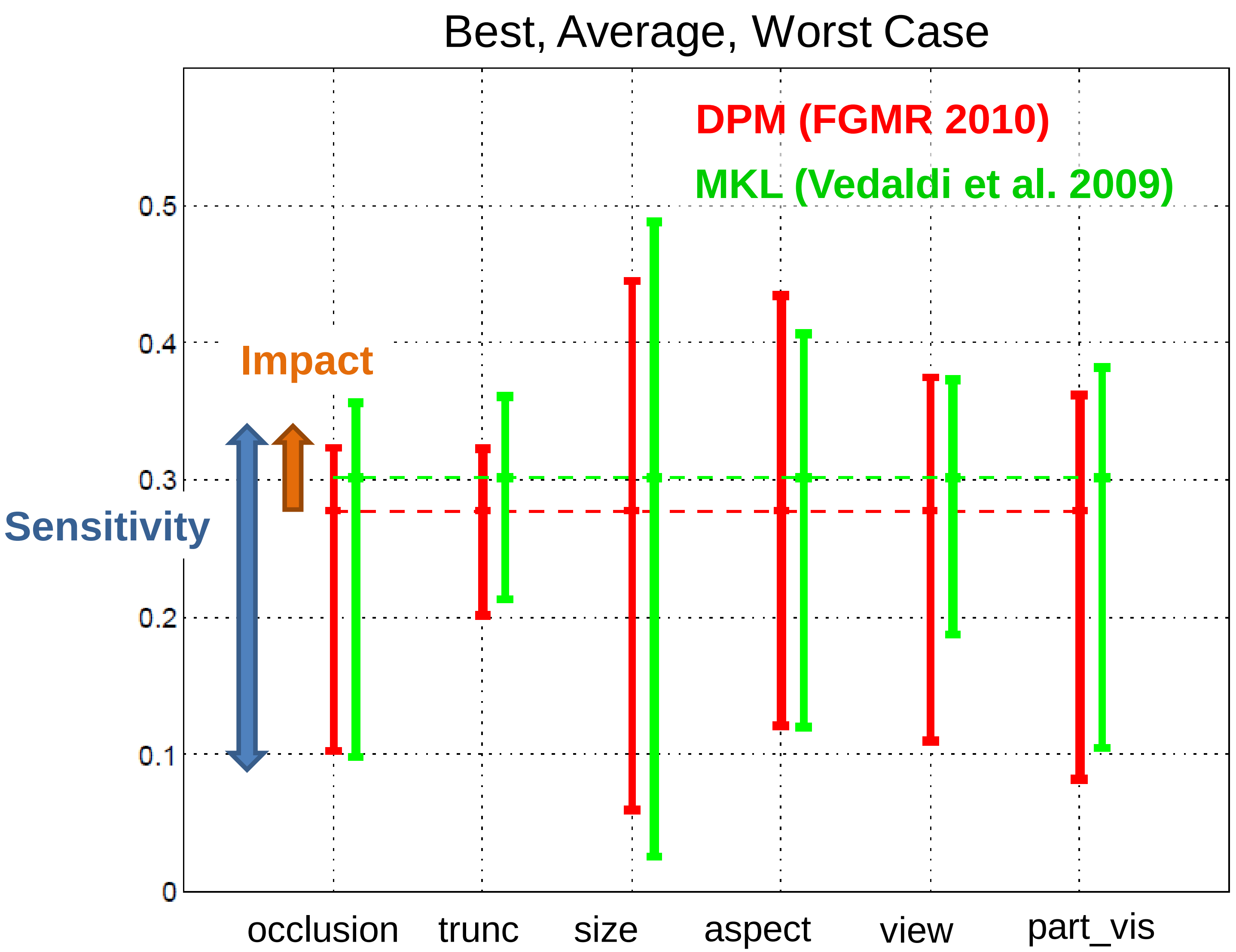

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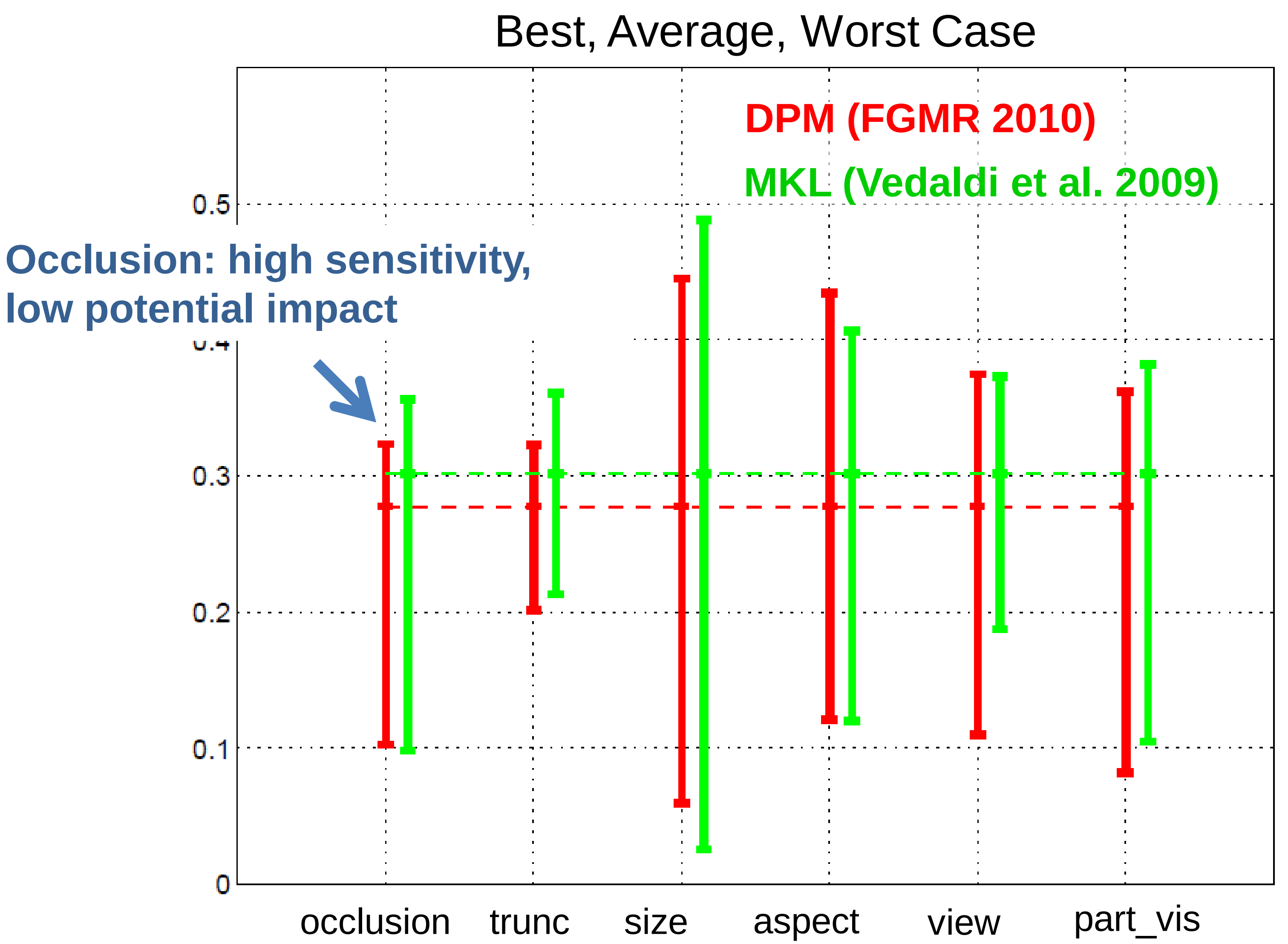

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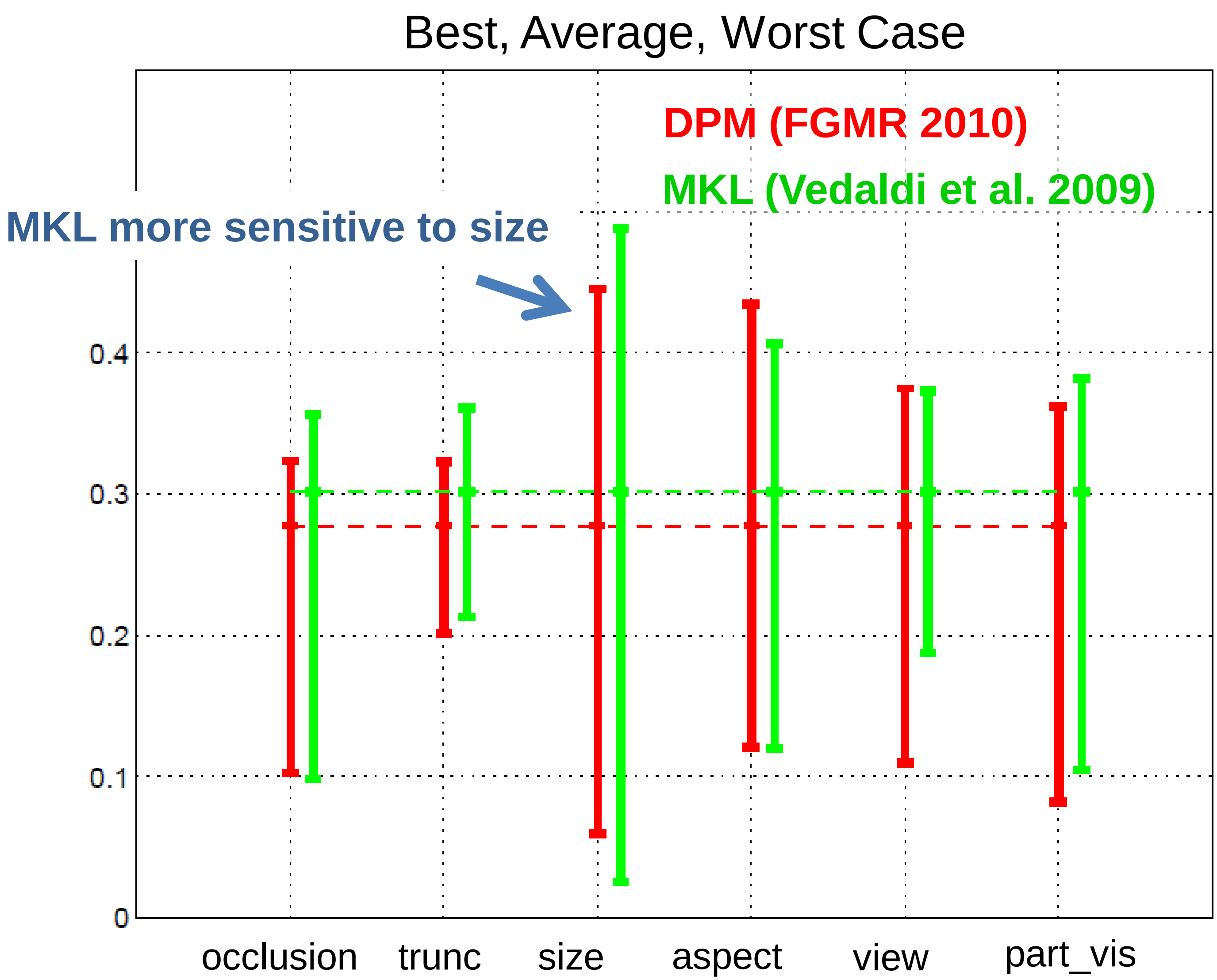

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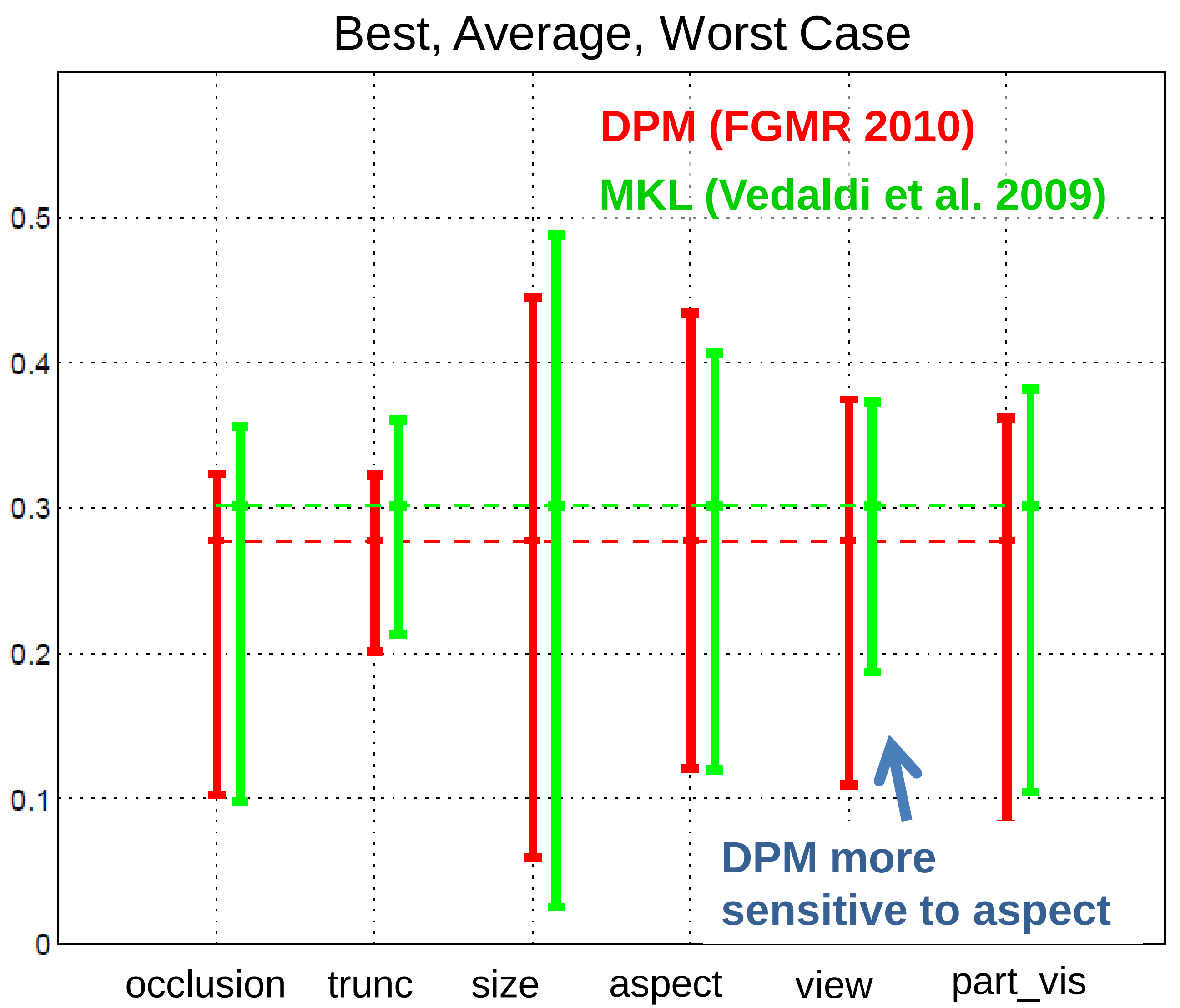


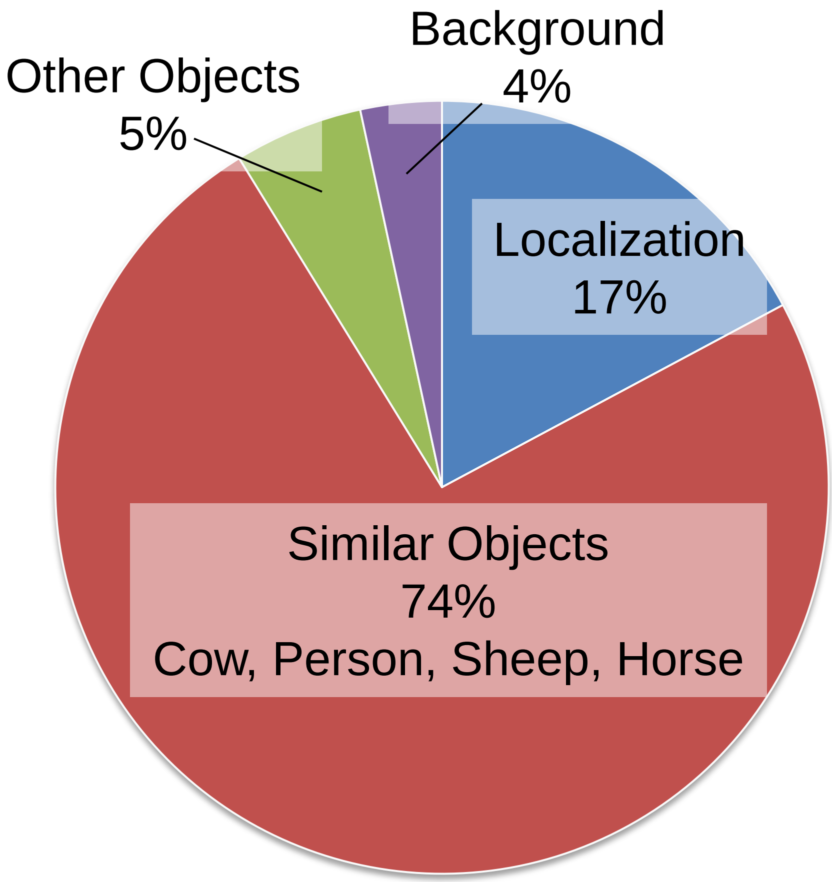
Conclusions

- Most errors that detectors make are reasonable
  - Localization error and confusion with similar objects
  - Misdetection of occluded or small objects
- Large improvements in specific areas (e.g., remove all background FPs or robustness to occlusion) has small impact in overall AP
  - More specific analysis should be standard
- Our code and annotations are available online
  - Automatic generation of analysis summary from standard annotations

www.cs.illinois.edu/homes/dhoiem/publications/detectionAnalysis_eccv12.tar.gz

Thank you!

Top Dog False Positives



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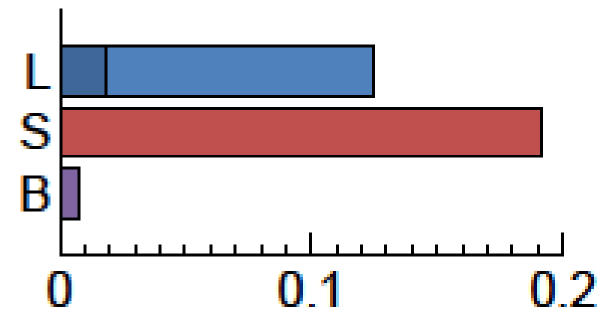

Top 5 FP

www.cs.illinois.edu/homes/dhoiem/publications/detectionAnalysis_eccv12.tar.gz