Diagnosing Error in Object Detectors

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(presented by Yuduo Wu)

Most of the slides are from Derek Hoiem's ECCV 2012 presentation

Object detection is a collection of problems

Intra-class Variation for "Airplane"

Occlusion




Shape




Viewpoint




Distance



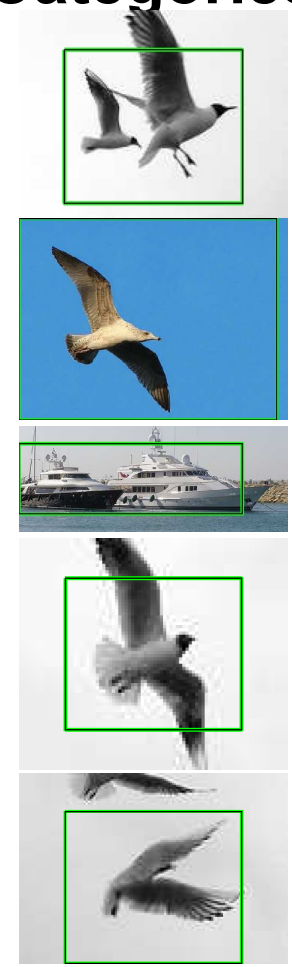


Object detection is a collection of problems

Confusing Distractors for “Airplane”

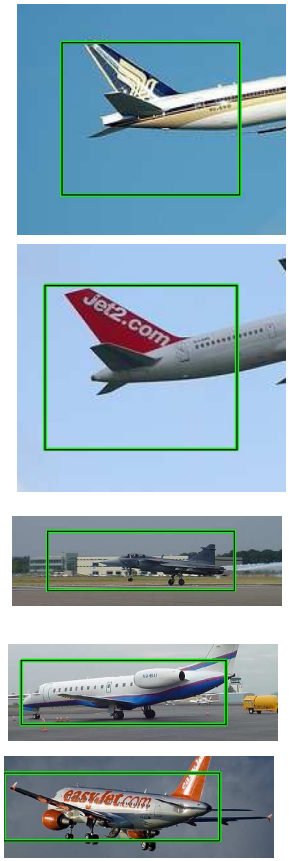
Background

Similar Categories



Dissimilar Categories

Localization Error

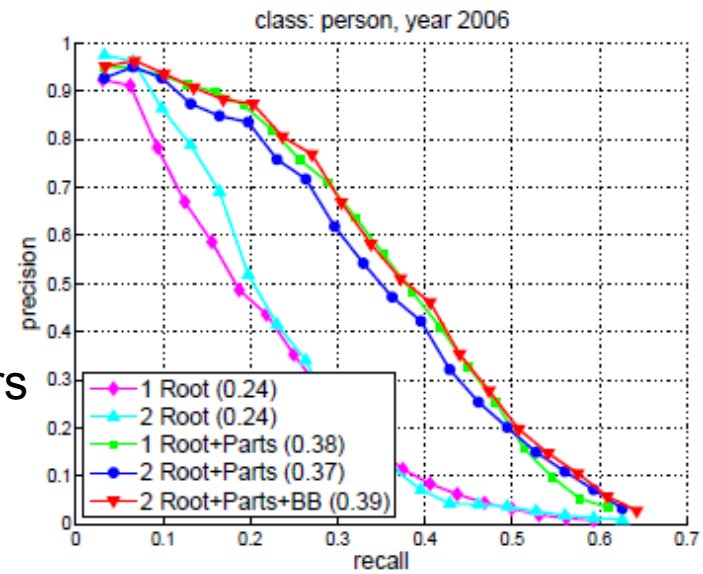


How to **evaluate** object detectors?

- Detector analysis tool is important
- 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



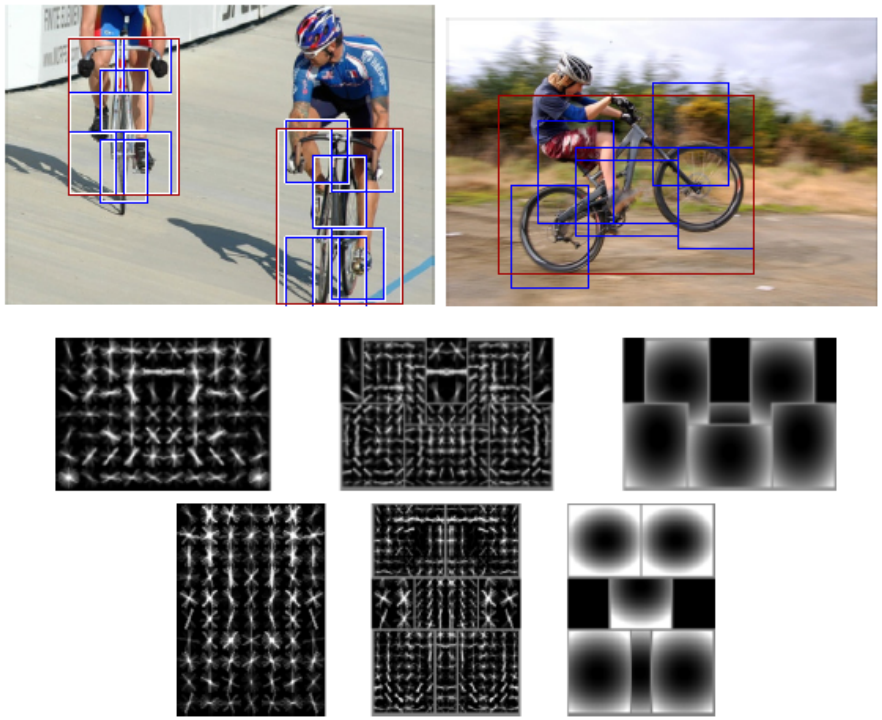
- Tools to evaluate detectors:
  - where detectors fail and succeed
  - potential impact of particular improvements

figs from Felzenszwalb et al. 2010

Detectors Analyzed as **Examples** on VOC 2007

Deformable Parts Model (DPM)

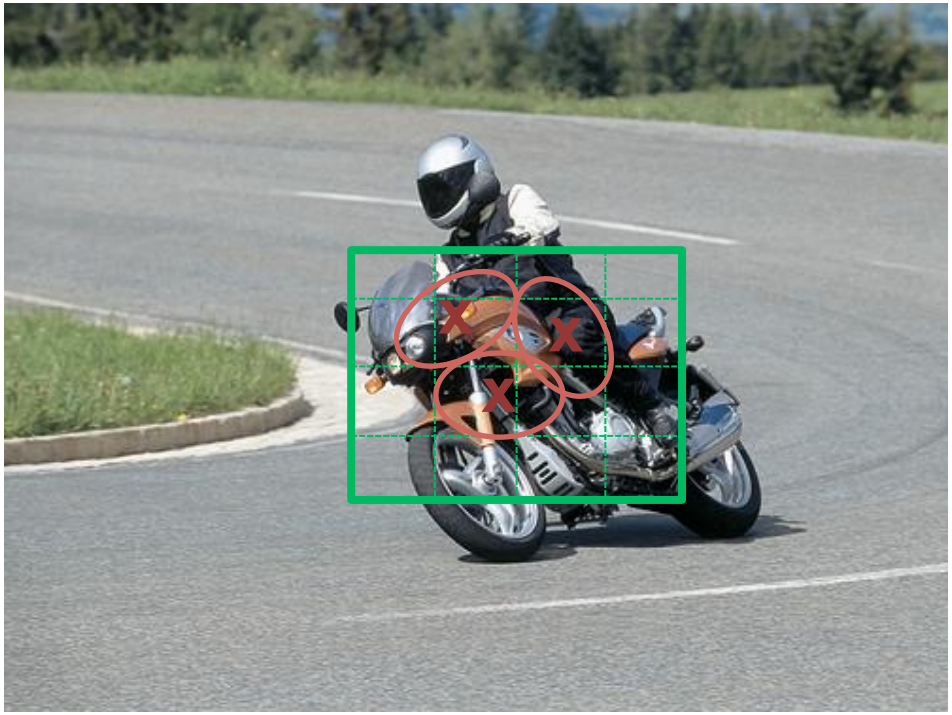
- Sliding window
- Mixture of HOG templates with latent HOG parts



Felzenszwalb et al. 2010 (v4)

Multiple Kernel Learning (MKL)

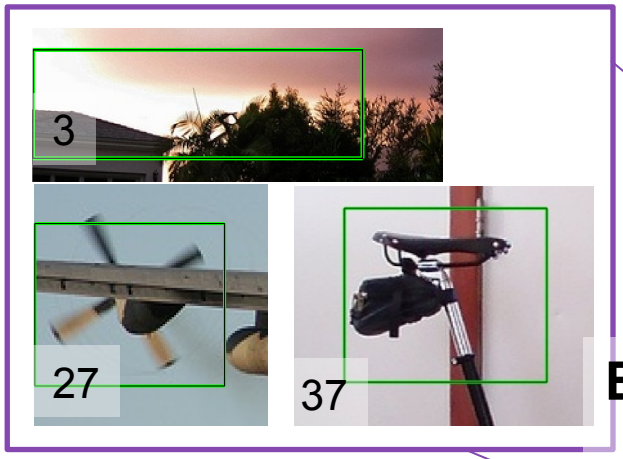
- Jumping window
- Various spatial pyramid bag of words features combined with MKL

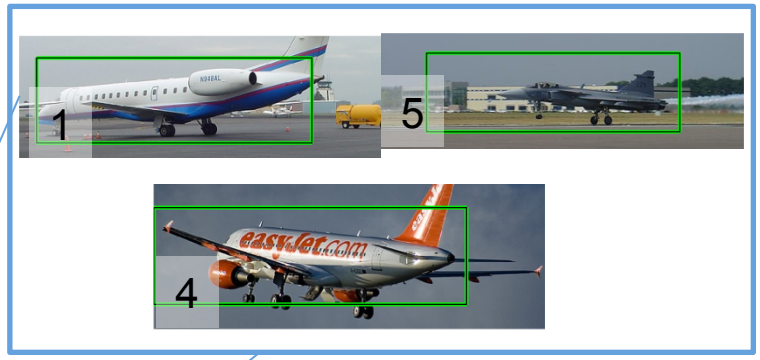


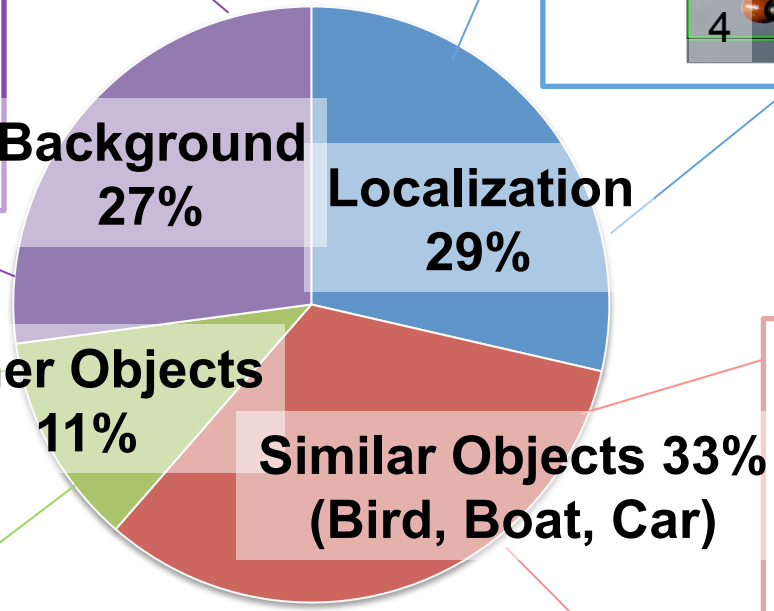
Vedaldi et al. 2009

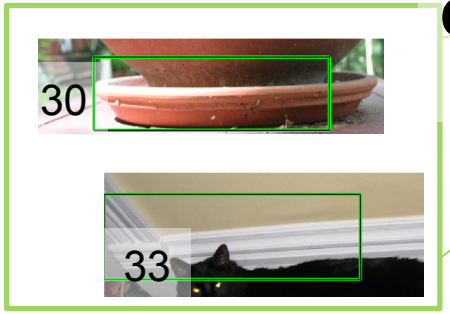
Top **false positives**: Airplane (**DPM**)

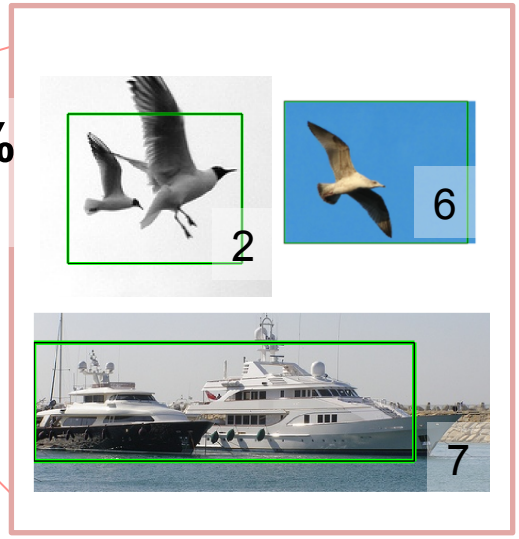
AP = 0.36



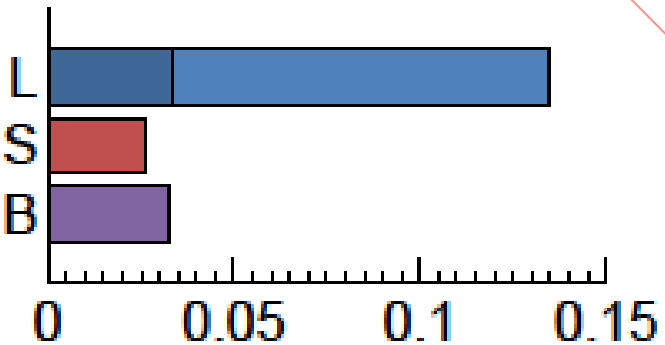






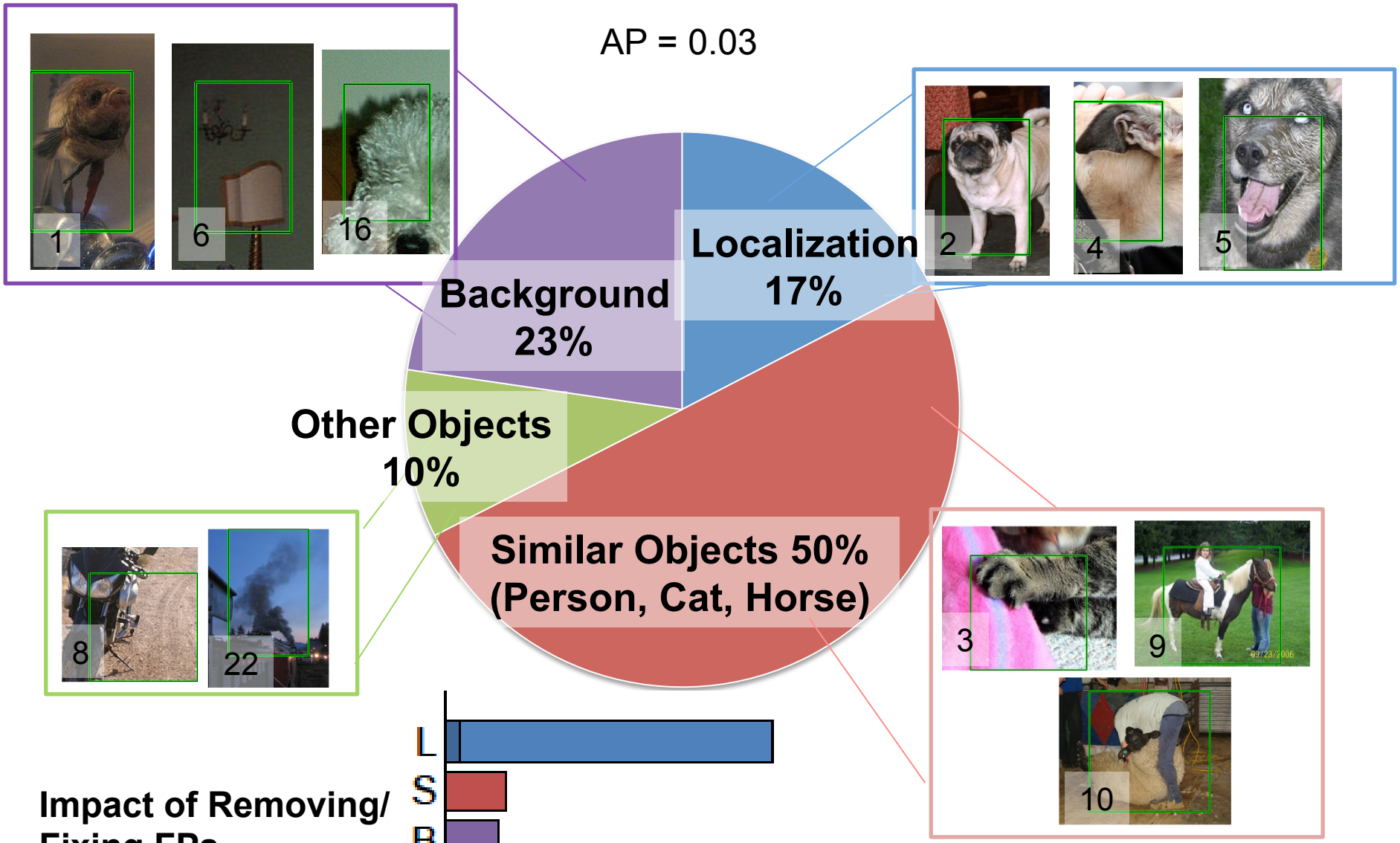


Impact of Removing/ Fixing FPs



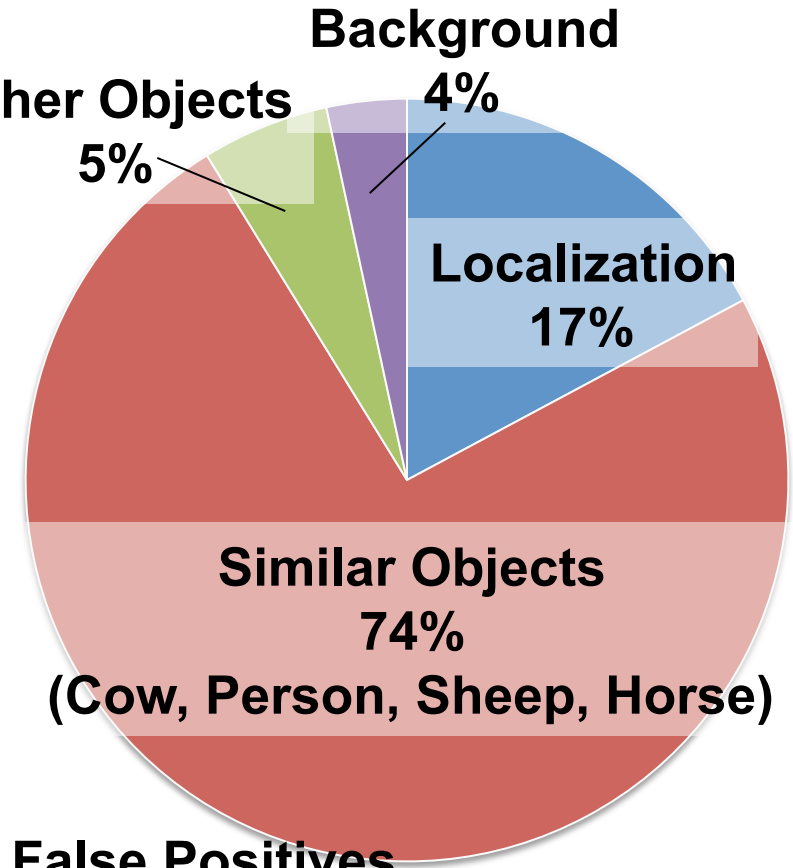
Top **false positives**: Dog (**DPM**)

AP = 0.03



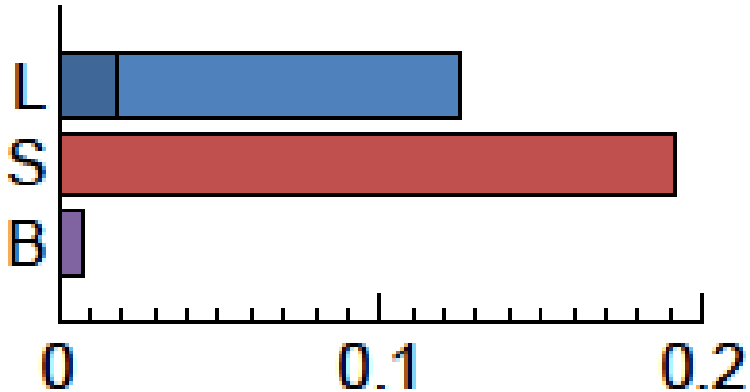
Impact of Removing/ Fixing FPs

Top **false positives**: Dog (**MKL**)



AP = 0.17

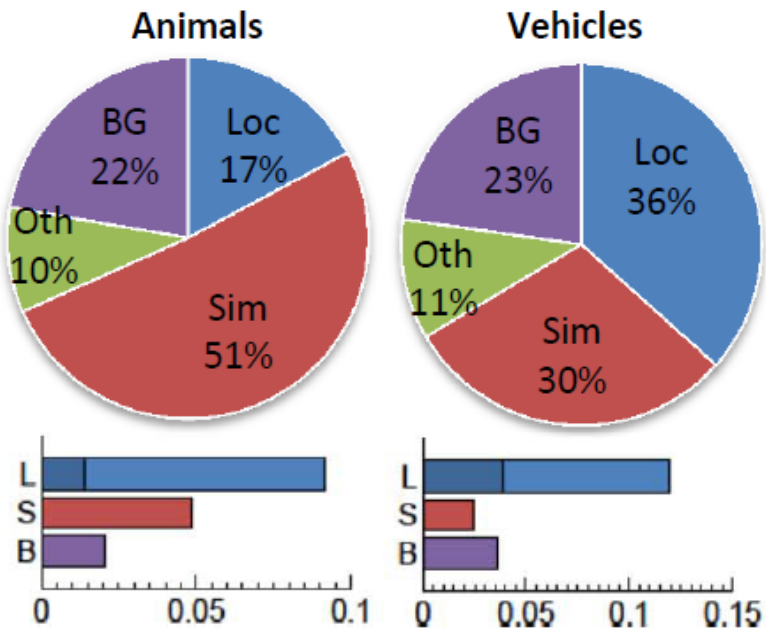
Impact of Removing/ Fixing FPs



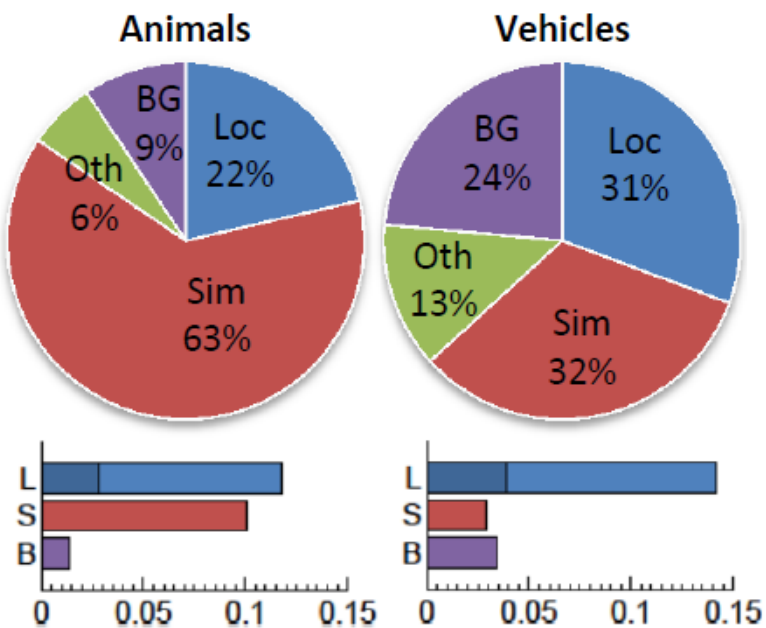
Top 5 False Positives

Summary of False Positive Analysis

DPM v4
(FGMR 2010)



MKL
(Vedaldi et al. 2009)



Biggest Improvement:
Localization Error

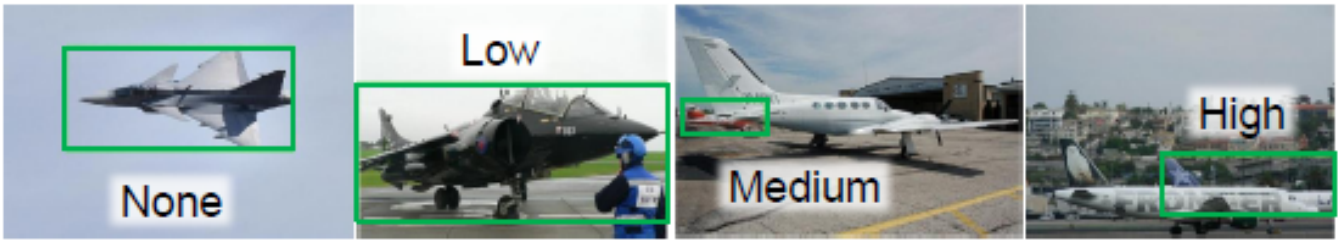
Small Improvement:
Background
Dissimilar Objects

MKL more reasonable than the DPM detectors

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



Example of occlusion for aeroplane class

Normalized Average Precision

- Average precision is **sensitive** to number of positive examples

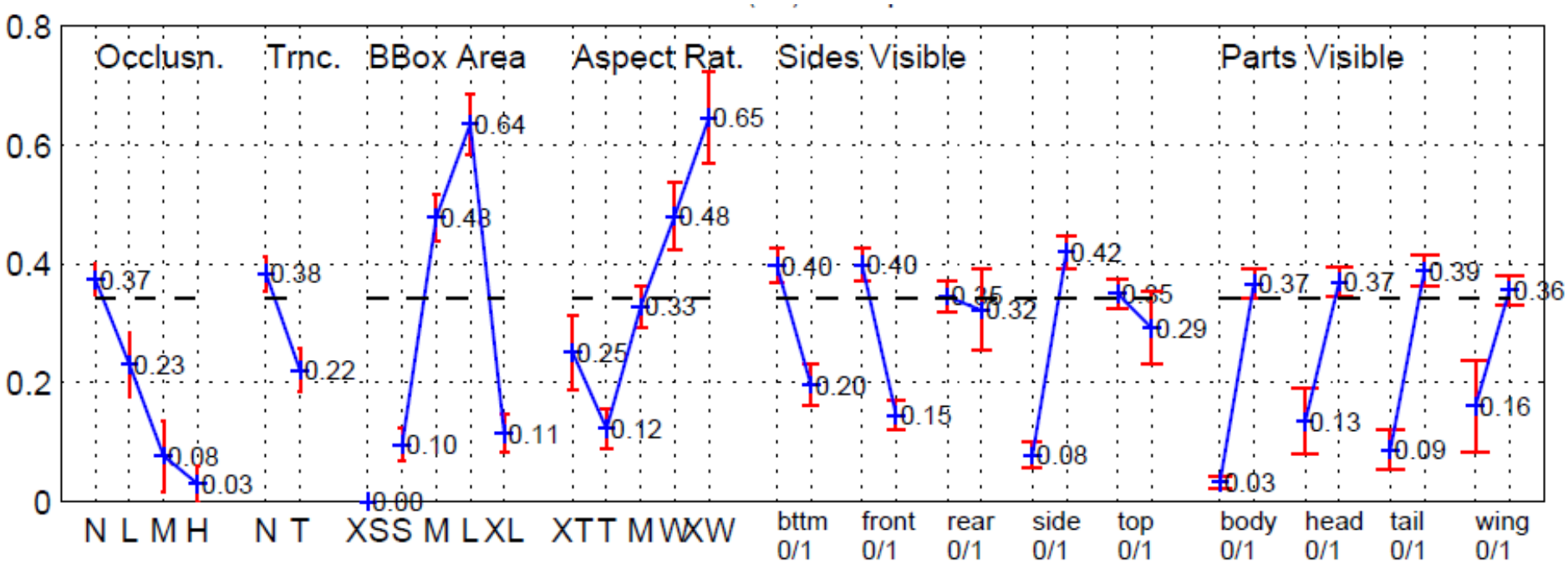
$$Precision = \frac{TruePositive}{TruePositive + FalsePositive}$$

$$TruePositive = Recall * Nj$$

Number of object examples in subset j

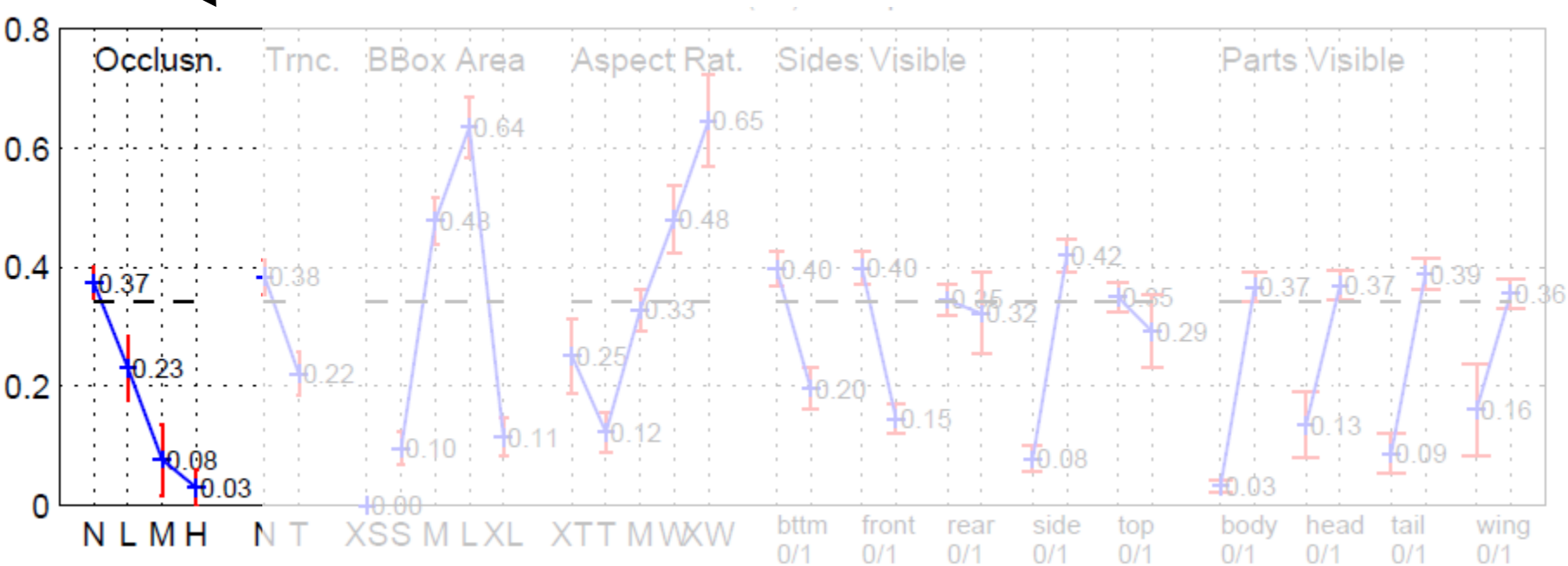
- **Normalized** average precision:
  - replace variable N_j with **fixed** N

Object characteristics: Aeroplane



Object characteristics: Aeroplane

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

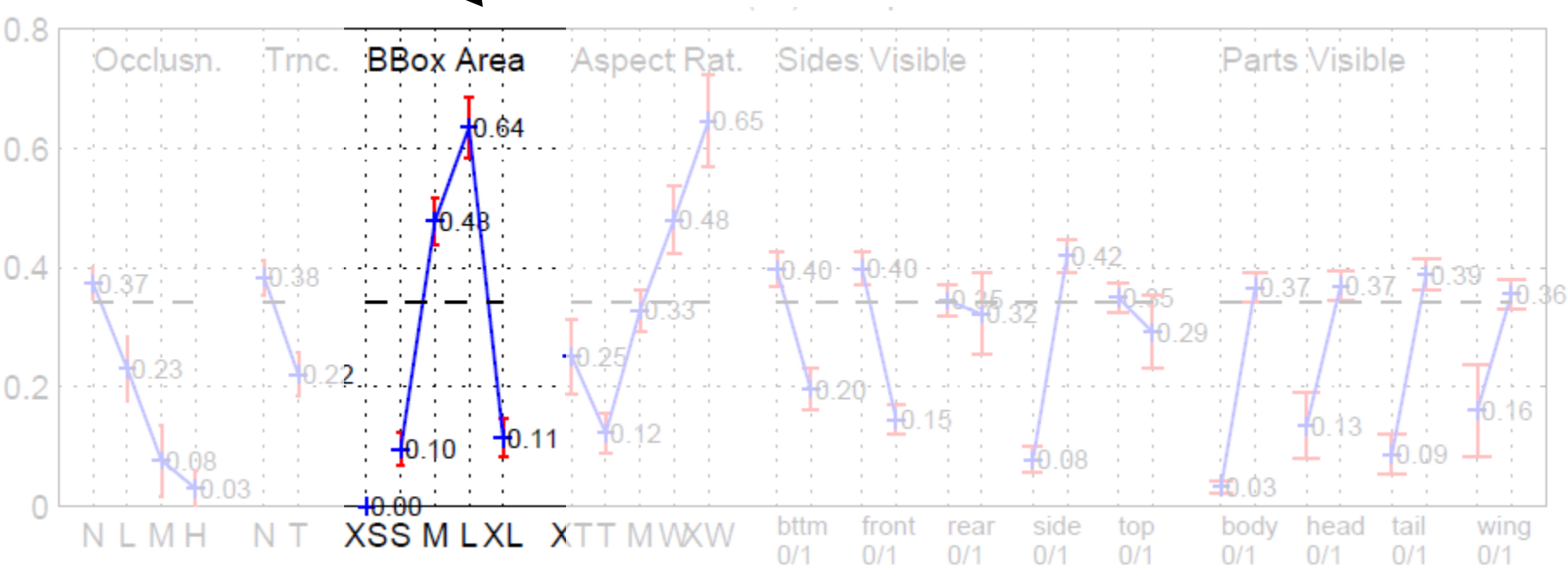





Easier (None) Harder (Heavy)

Object characteristics: Aeroplane

Size: strong preference for average to above average sized airplanes

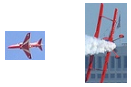


Large

Medium

X-Large

Small



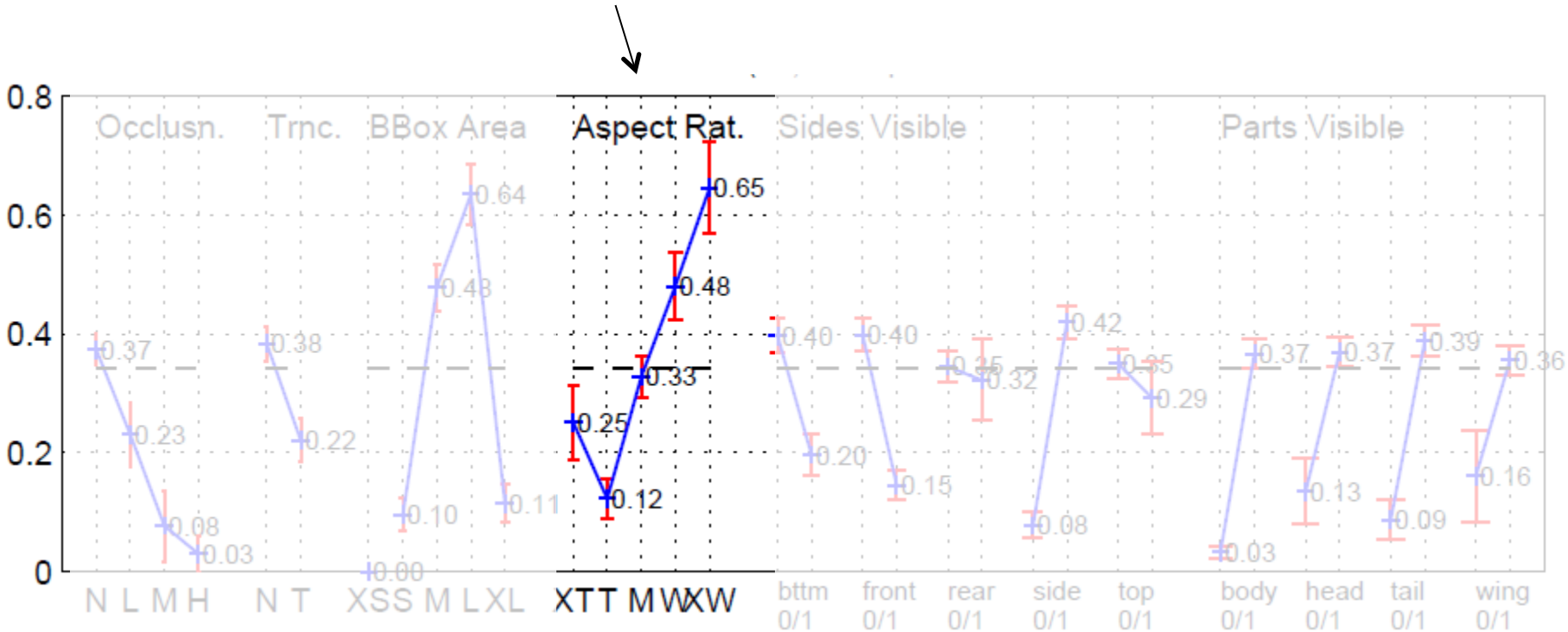
X-Small

Easier

Harder

Object characteristics: Aeroplane

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



X-Wide

Wide

Medium

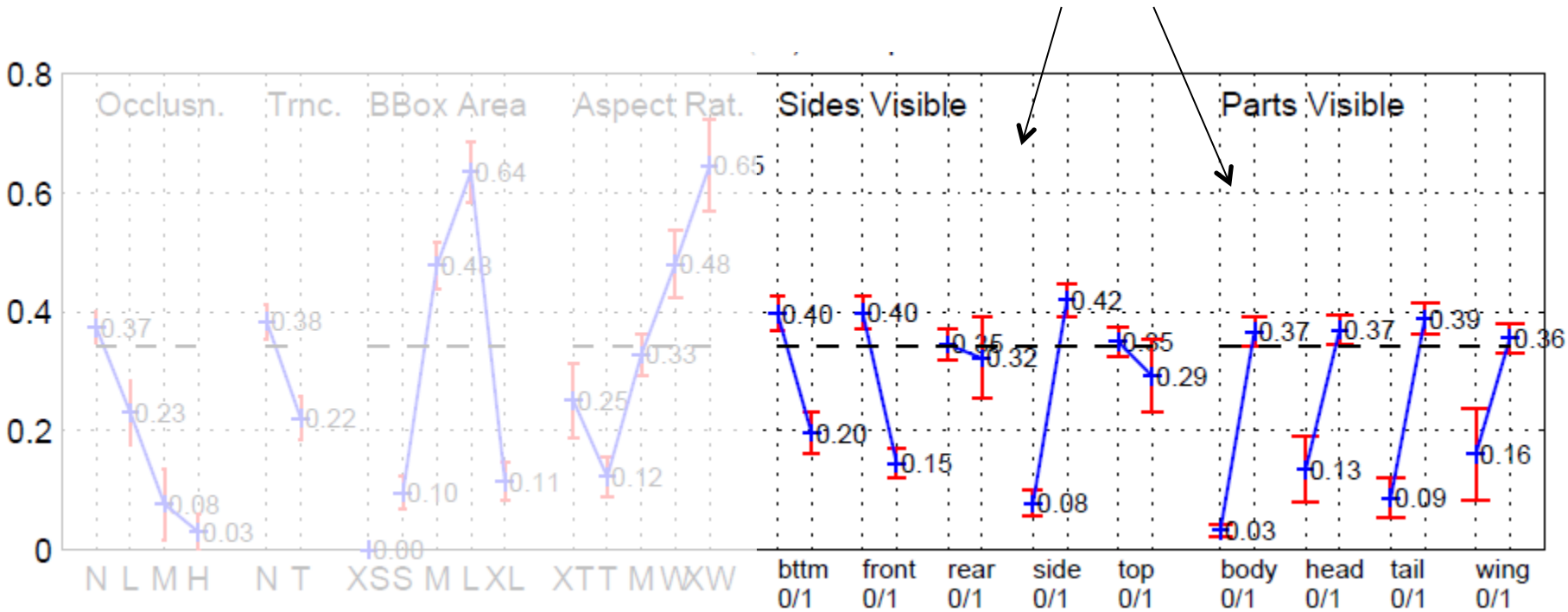
X-Tall

Tall

Easier (Wide) ⟷ Harder (Tall)

Object characteristics: Aeroplane

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



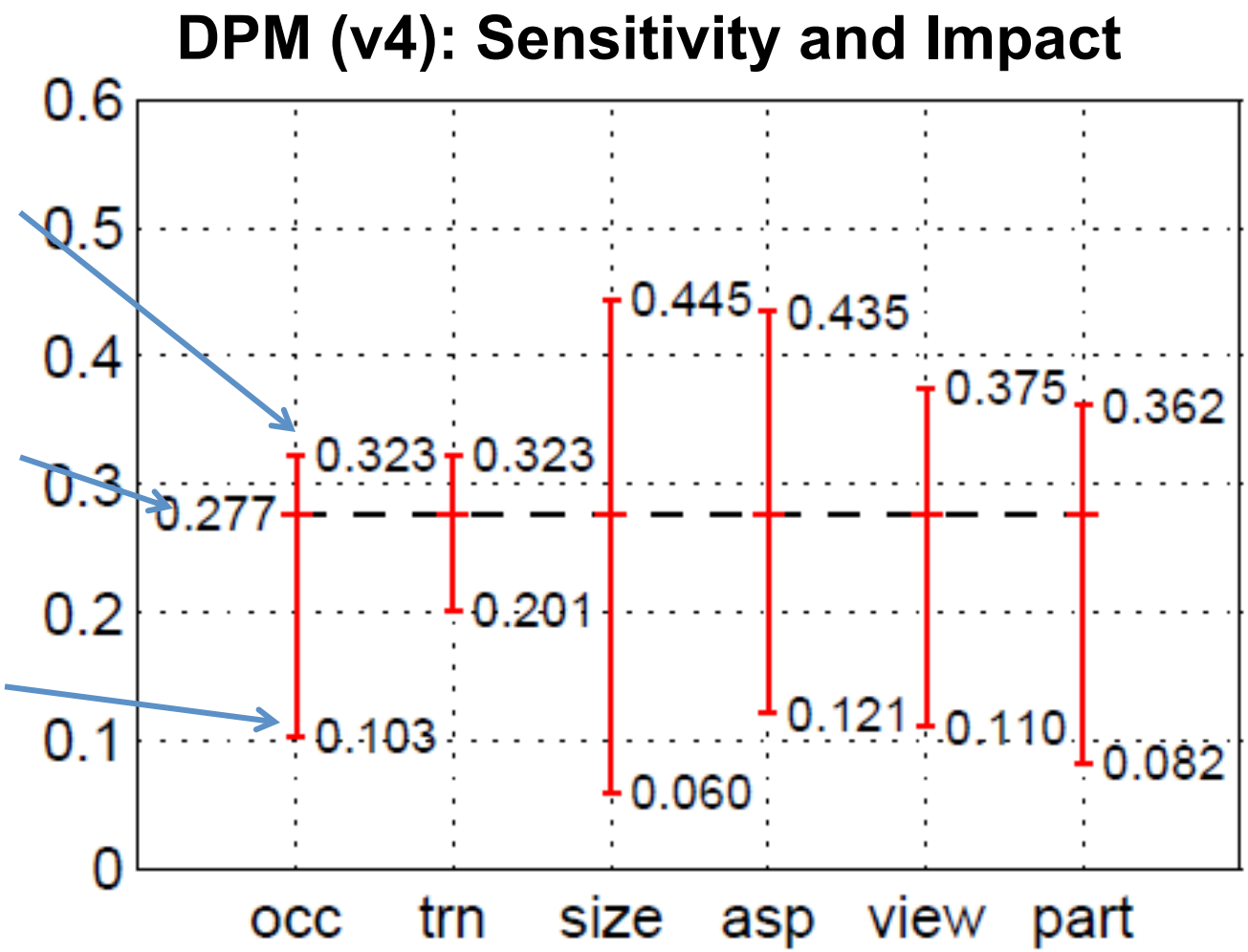
Easier (Side) Harder (Non-Side)

Summarizing Detector Performance

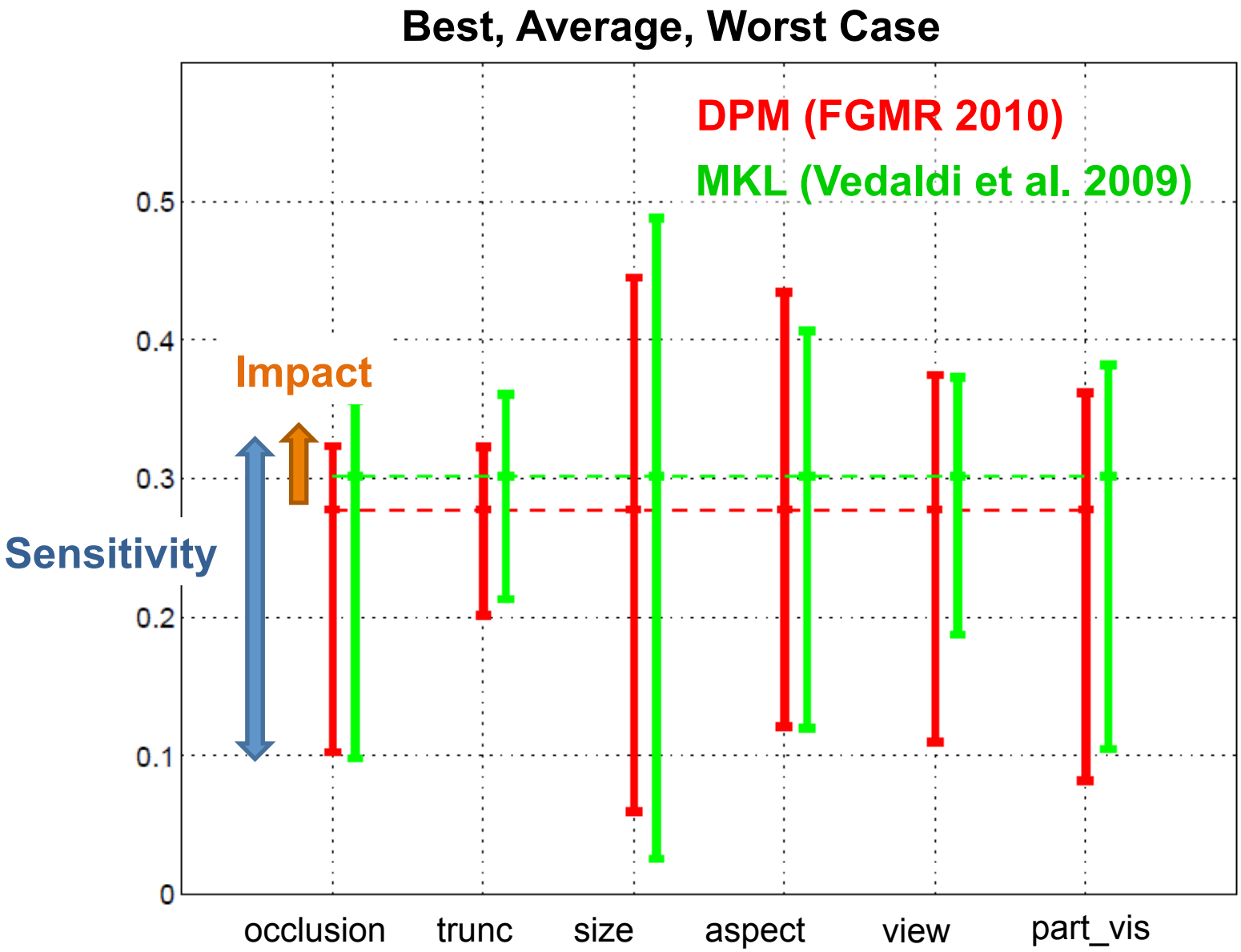
Avg. Performance of **Best Case**

Avg. **Overall** Performance

Avg. Performance of **Worst Case**

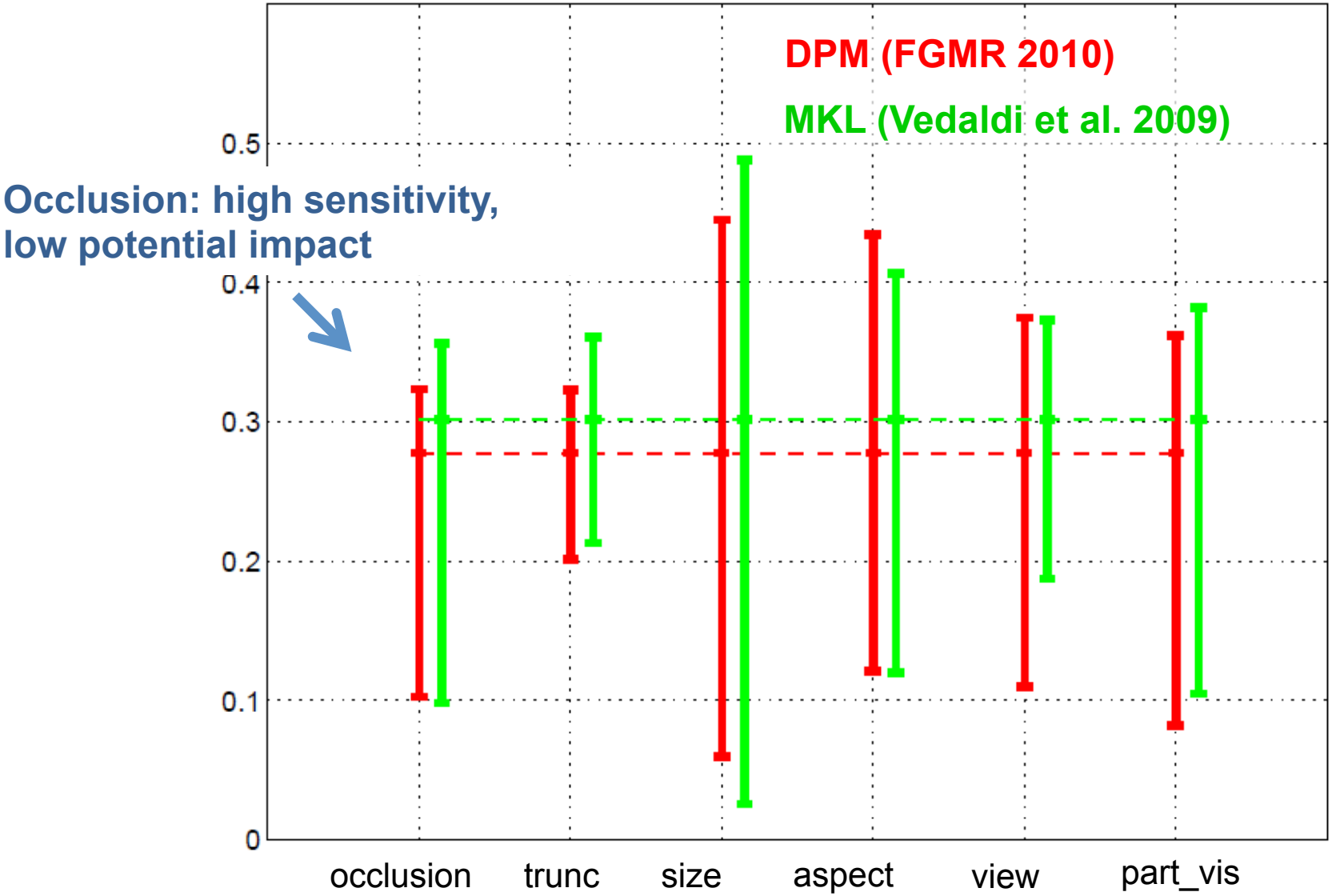


Summarizing Detector Performance

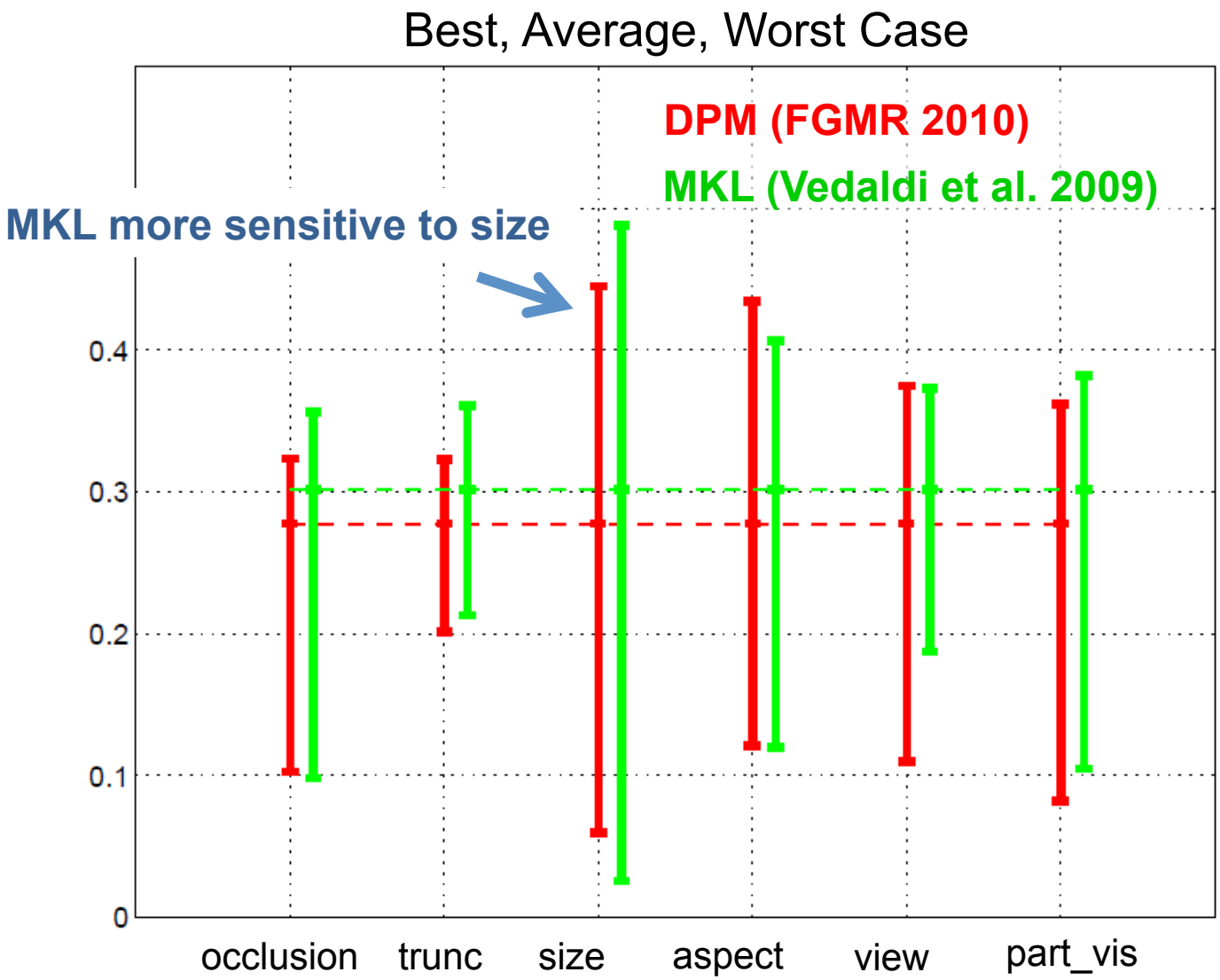


Summarizing Detector Performance

Best, Average, Worst Case



Summarizing Detector Performance



Conclusions

- **Most errors 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

More Information:
www.cs.illinois.edu/homes/dhoiem/publications/detectionAnalysis_eccv12.tar.gz
or:
http://videolectures.net/eccv2012_hoiem_detectors/?q=eccv%202012

Thank you!