The PASCAL Visual Object Classes Challenge 2010 (VOC2010)

Part 2 – Detection Task

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PASCAL2

Pattern Analysis, Statistical Modelling and Computational Learning

Detection Challenge

- Predict the bounding boxes of all objects of a given class in an image (if any)

- Competition 3: Train on the supplied data
  - Which methods perform best given specified training data?

- Competition 4: Train on any (non-test) data
  - How well do state-of-the-art methods perform on these problems?

Average Precision: VOC2010
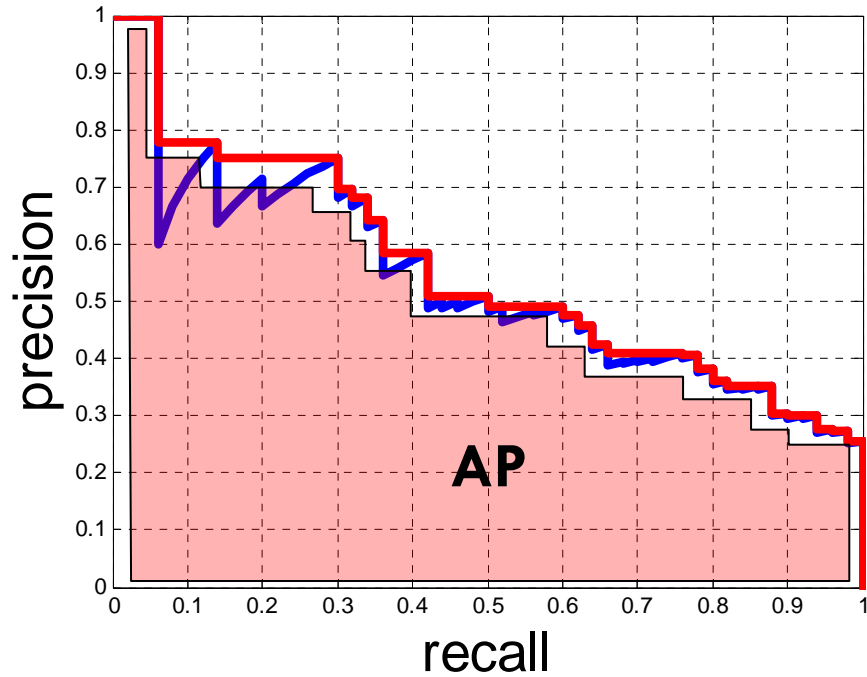
- Interpolate curve to create version for which the precision is monotonically non-increasing

- Measure area under interpolated curve

- Sawtooth shape is ignored

- Area is measured with maximum accuracy

- Good score requires both high precision **and** recall

Evaluating Bounding Boxes

- ## Area of Overlap (AO) Measure

Ground truth B_{gt}

$B_{gt} \cap B_p$

Predicted B_p
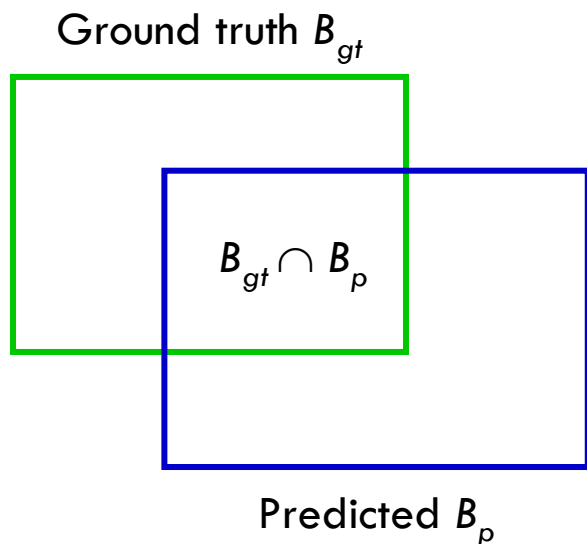
$$AO(B_{gt}, B_p) = \frac{|B_{gt} \bigcap B_p|}{|B_{gt} \bigcup B_p|}$$

- Need to define a threshold *t* such that $AO(B_{gt}, B_p)$ implies a correct detection: 50%
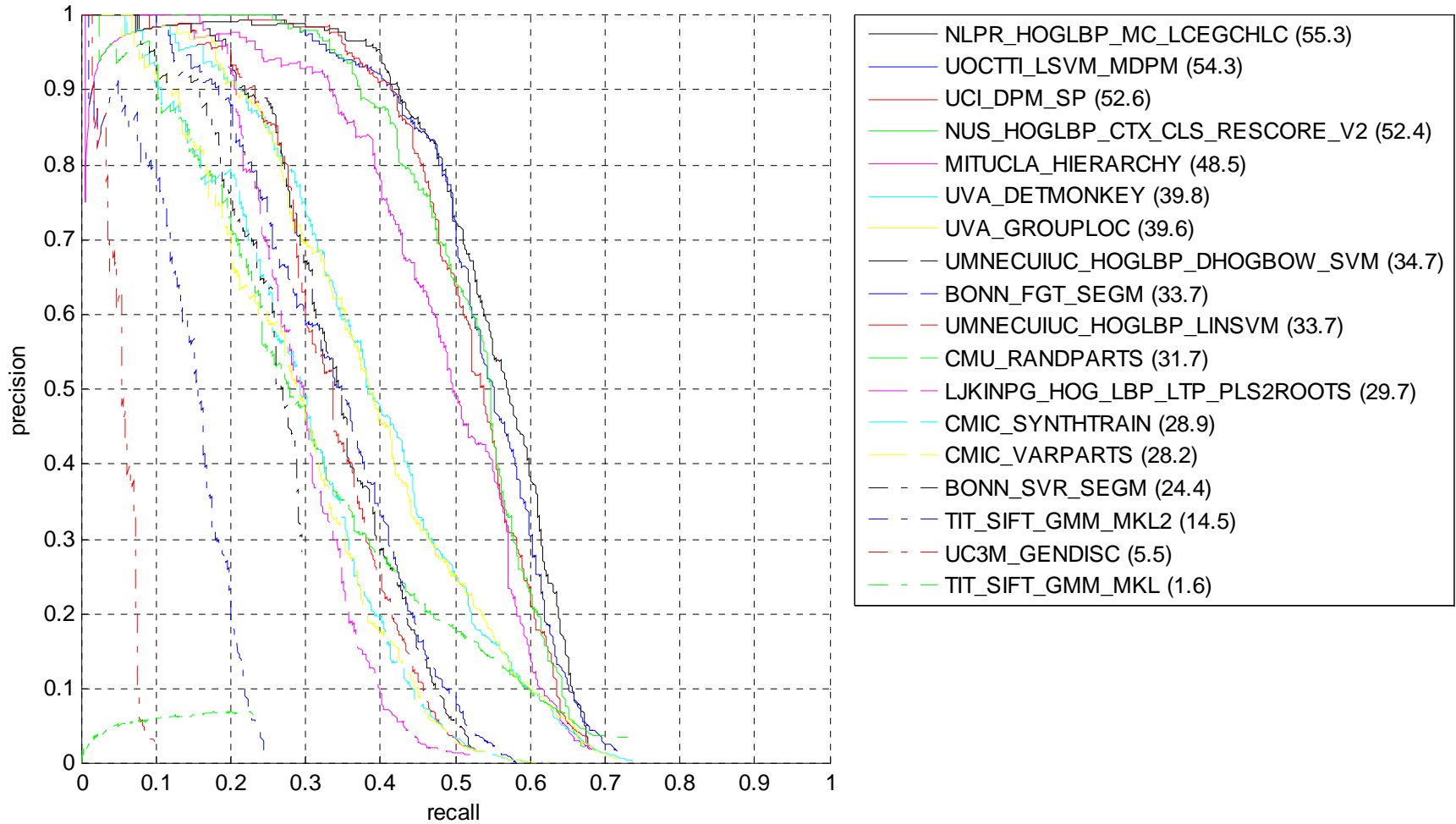
Methods

- ## 22 Methods, 15 Groups
  - VOC2009: 18 Methods, 12 Groups
- ## Methods
  - Sliding window, SVM, multiple features e.g. HOG, LBP
  - Parts-based models, hierarchical models
  - Segmentation-based object hypotheses ("jumping window")
  - Combination with whole-image classification
- ## Use of external training data
  - Additional data (e.g. annotated with Mechanical Turk)
  - More detailed annotation e.g. parts
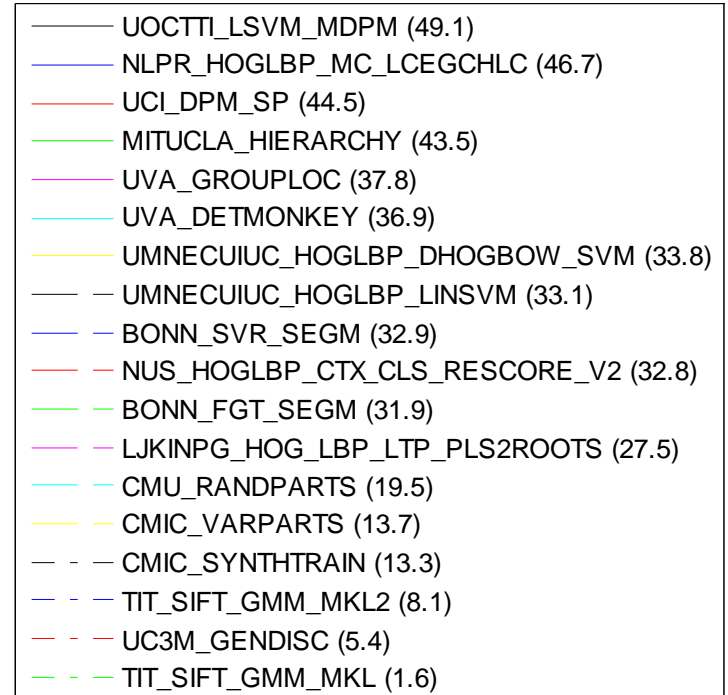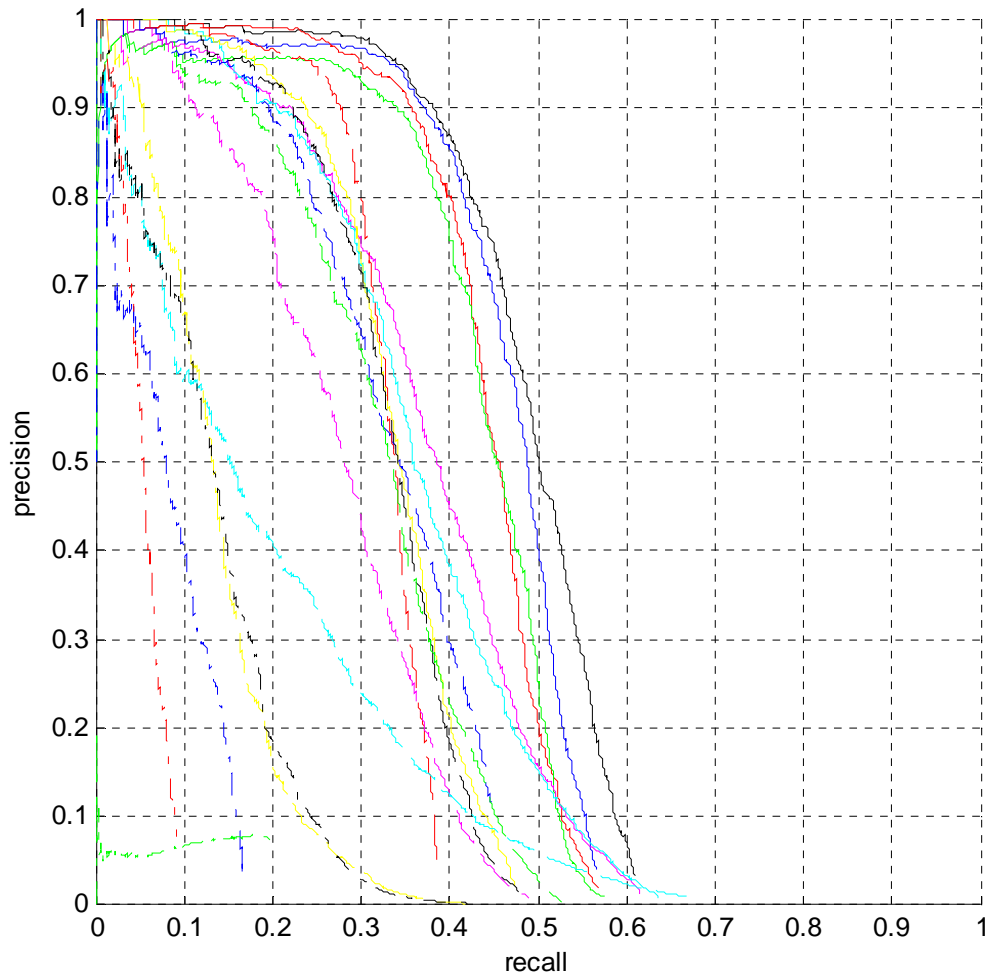
AP by Class/Method

(1st, 2nd, 3rd place)

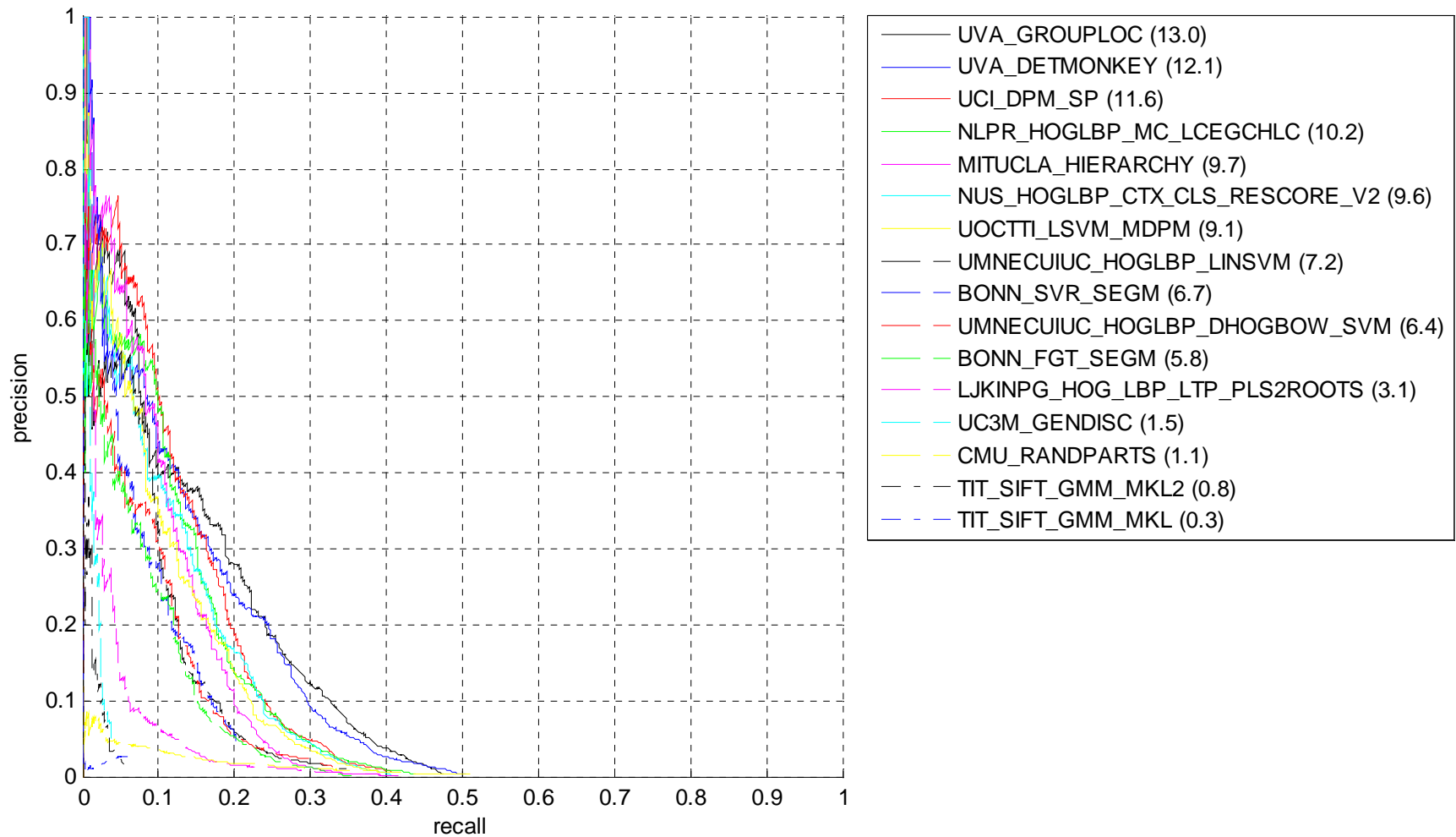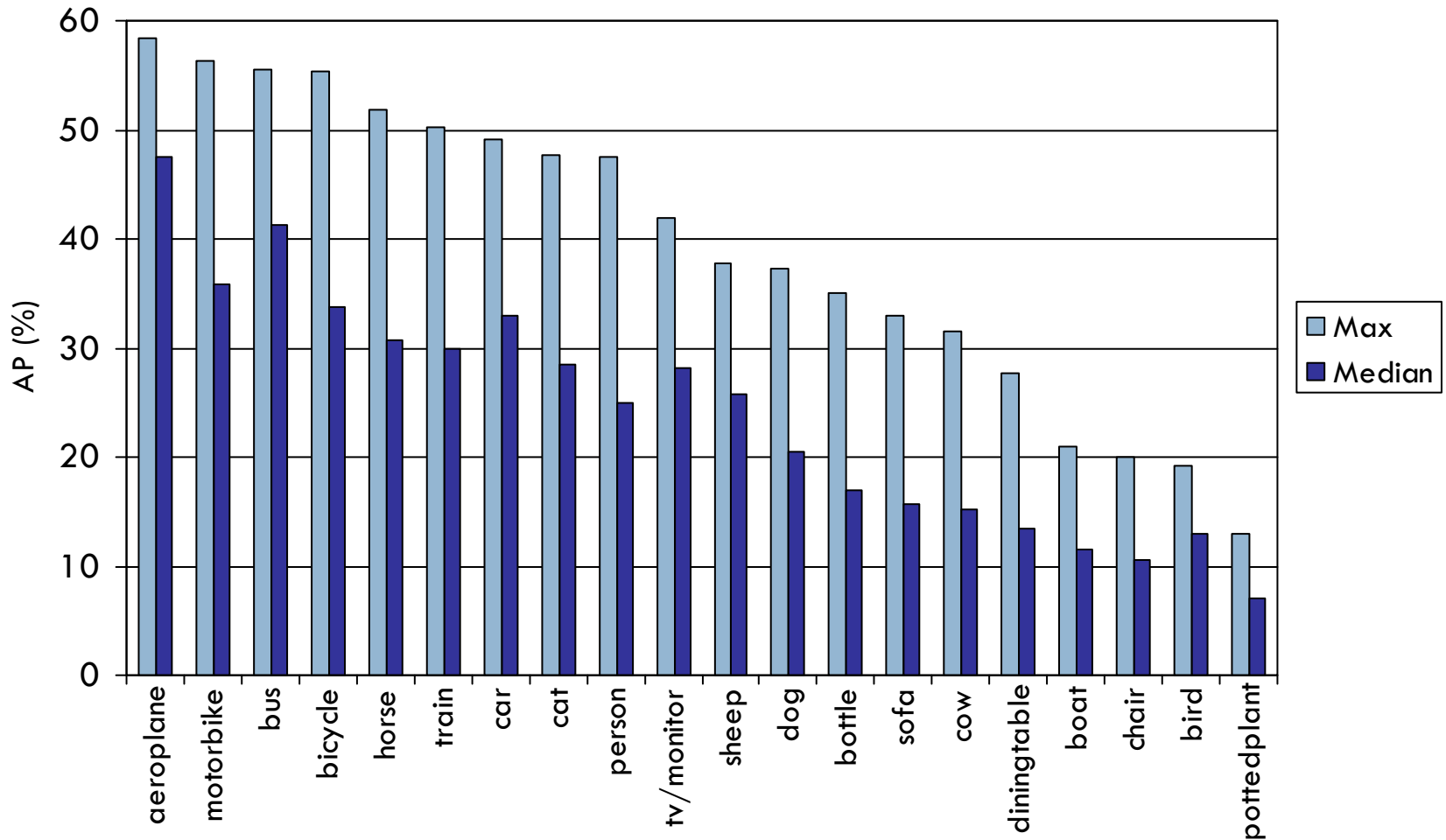|	aero plane	bicycle	bird	boat	bottle	bus	car	cat	chair	cow	dining table	dog	horse	motor bike	person	potted plant	sheep	sofa	train	tv/ monitor
BONN_FGT_SEGM	52.7	33.7	13.2	11.0	14.2	43.1	31.9	35.6	5.7	25.4	14.4	20.6	38.1	41.7	25.0	5.8	26.3	18.1	37.6	28.1
BONN_SVR_SEGM	50.5	24.4	17.1	13.3	10.9	39.5	32.9	36.5	5.6	16.0	6.6	22.3	24.9	29.0	29.8	6.7	28.4	13.3	32.1	27.2
CMIC_SYNTHTRAIN	-	28.9	-	-	-	30.2	13.3	-	-	-	-	-	26.2	28.1	13.2	-	-	-	18.8	25.7
CMIC_VARPARTS	-	28.2	-	-	-	26.9	13.7	-	-	-	-	-	23.5	24.7	16.1	-	-	-	18.8	24.5
CMU_RANDPARTS	23.8	31.7	1.2	3.4	11.1	29.7	19.5	14.2	0.8	11.1	7.0	4.7	16.4	31.5	16.0	1.1	15.6	10.2	14.7	21.0
CMU_RANDPARTS_MAXSCORE	-	-	2.7	-	-	-	-	16.2	-	10.6	8.5	-	-	-	17.9	-	-	-	15.7	-
LJKINPG_HOG_LBP_LTP_PLS2ROOTS	32.7	29.7	0.8	1.1	19.8	39.4	27.5	8.6	4.5	8.1	6.3	11.0	22.9	34.1	24.6	3.1	24.0	2.0	23.5	27.0
MITUCLA_HIERARCHY	54.2	48.5	15.7	19.2	29.2	55.5	43.5	41.7	16.9	28.5	26.7	30.9	48.3	55.0	41.7	9.7	35.8	30.8	47.2	40.8
NLPR_HOGLBP_MC_LCEGCHLC	53.3	55.3	19.2	21.0	30.0	54.4	46.7	41.2	20.0	31.5	20.7	30.3	48.6	55.3	46.5	10.2	34.4	26.5	50.3	40.3
NUS_HOGLBP_CTX_CLS_RESCORE_V2	49.1	52.4	17.8	12.0	30.6	53.5	32.8	37.3	17.7	30.6	27.7	29.5	51.9	56.3	44.2	9.6	14.8	27.9	49.5	38.4
TIT_SIFT_GMM_MKL	10.5	1.6	1.2	0.9	0.1	2.8	1.6	6.7	0.1	2.0	0.4	3.0	2.0	4.4	2.0	0.3	1.1	1.2	2.1	1.9
TIT_SIFT_GMM_MKL2	20.0	14.5	3.8	1.2	0.5	17.6	8.1	28.5	0.1	2.9	3.1	17.5	7.2	18.8	3.3	0.8	2.9	6.3	7.6	1.1
UC3M_GENDISC	15.8	5.5	5.6	2.3	0.3	10.2	5.4	12.6	0.5	5.6	4.5	7.7	11.3	12.6	5.3	1.5	2.0	5.9	9.1	3.2
UCI_DPM_SP	46.1	52.6	13.8	15.5	28.3	53.2	44.5	26.6	17.6	-	16.1	20.4	45.5	51.2	43.5	11.6	30.9	20.3	47.6	-
UMNECUIUC_HOGLBP_DHOGBOW_SVM	40.4	34.7	2.7	8.4	26.0	43.1	33.8	17.2	11.2	14.3	14.4	14.9	31.8	37.3	30.0	6.4	25.2	11.6	30.0	35.7
UMNECUIUC_HOGLBP_LINSVM	37.9	33.7	2.7	6.5	25.3	37.5	33.1	15.5	10.9	12.3	12.5	13.7	29.6	34.5	33.8	7.2	22.9	9.9	28.9	34.1
UOCTTI_LSVM_MDPM	52.4	54.3	13.0	15.6	35.1	54.2	49.1	31.8	15.5	26.2	13.5	21.5	45.4	51.6	47.5	9.1	35.1	19.4	46.6	38.0
UVA_DETMONKEY	56.7	39.8	16.8	12.2	13.8	44.9	36.9	47.7	12.1	26.9	26.5	37.2	42.1	51.9	25.7	12.1	37.8	33.0	41.5	41.7
UVA_GROUPLOC	58.4	39.6	18.0	13.3	11.1	46.4	37.8	43.9	10.3	27.5	20.8	36.0	39.4	48.5	22.9	13.0	36.8	30.5	41.2	41.9

# Precision/Recall - Bicycle

Precision/Recall - Car

Legend:
- UOCTTI_LSVM_MDPM (49.1)
- NLPR_HOGLBP_MC_LCEGCHLC (46.7)
- UCI_DPM_SP (44.5)
- MITUCLA_HIERARCHY (43.5)
- UVA_GROUPLOC (37.8)
- UVA_DETMONKEY (36.9)
- UMNECUIUC_HOGLBP_DHOGBOW_SVM (33.8)
- UMNECUIUC_HOGLBP_LINSVM (33.1)
- BONN_SVR_SEGM (32.9)
- NUS_HOGLBP_CTX_CLS_RESCORE_V2 (32.8)
- BONN_FGT_SEGM (31.9)
- LJKINPG_HOG_LBP_LTP_PLS2ROOTS (27.5)
- CMU_RANDPARTS (19.5)
- CMIC_VARPARTS (13.7)
- CMIC_SYNTHTRAIN (13.3)
- TIT_SIFT_GMM_MKL2 (8.1)
- UC3M_GENDISC (5.4)
- TIT_SIFT_GMM_MKL (1.6)

Precision/Recall – Potted plant

AP by Class

Max AP: 58.4% (aeroplane) ... 13.0% (potted plant)

Median AP by Method
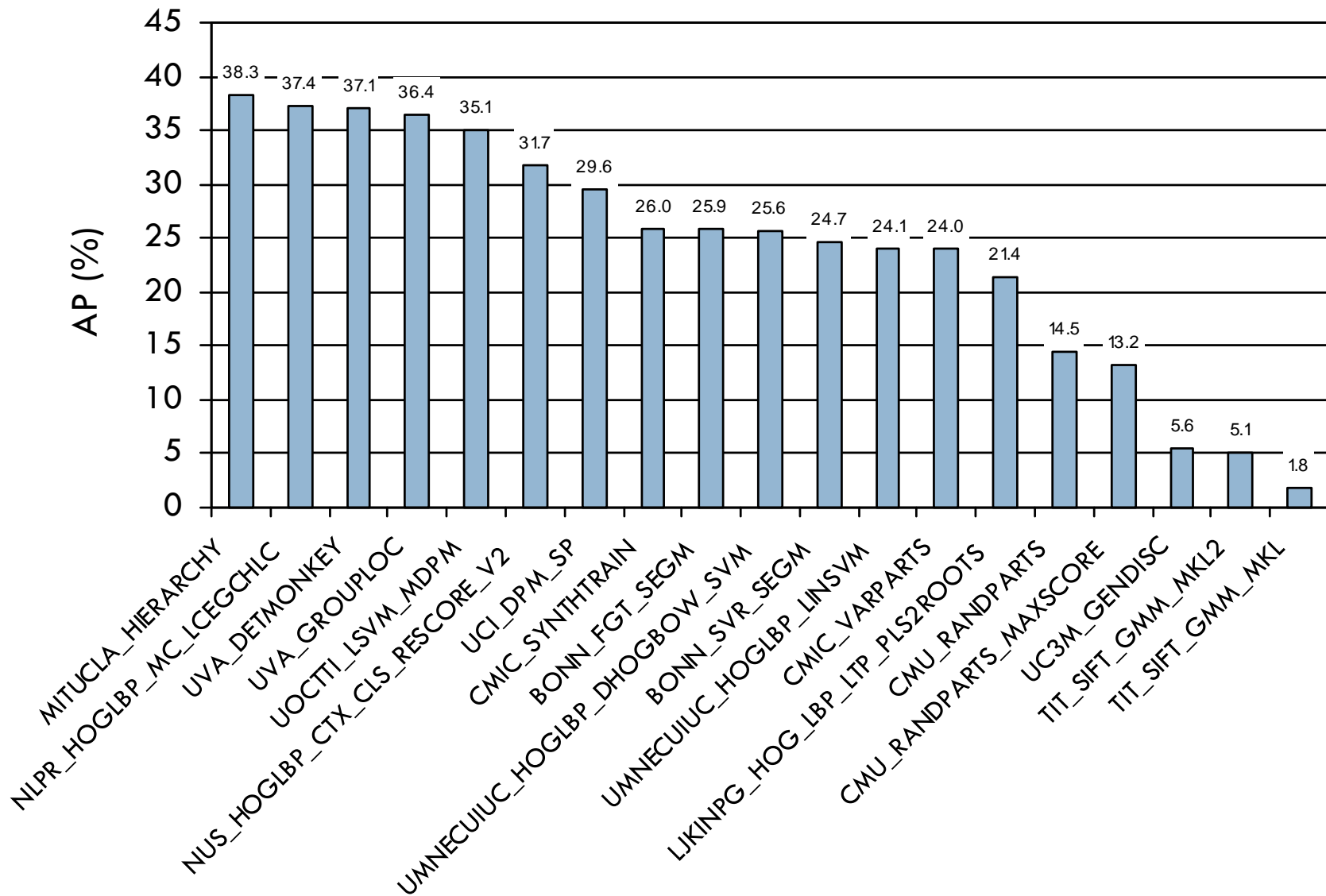
True Positives - Person

UOCTTI_LSVM_MDPM

NLPR_HOGLBP_MC_LCEGCHLC

NUS_HOGLBP_CTX_CLS_RESCORE_V2

False Positives - Person
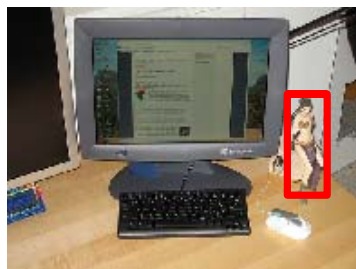
UOCTTI_LSVM_MDPM

NLPR_HOGLBP_MC_LCEGCHLC
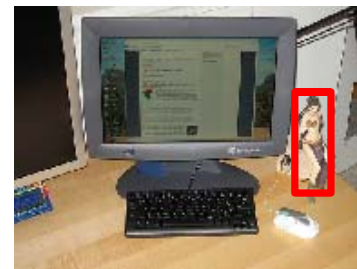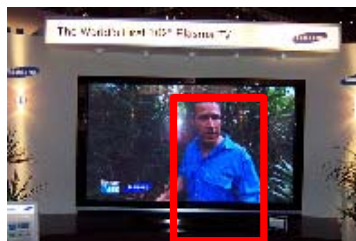
NUS_HOGLBP_CTX_CLS_RESCORE_V2

"Near Misses" - Person

UOCTTI_LSVM_MDPM

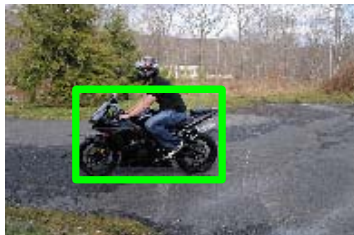## NLPR_HOGLBP_MC_LCEGCHLC
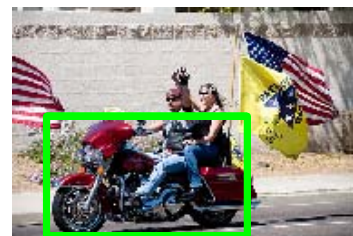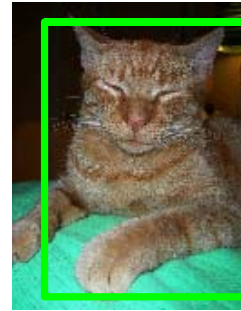

NUS_HOGLBP_CTX_CLS_RESCORE_V2

True Positives - Motorbike

MITUCLA_HIERARCHY

NLPR_HOGLBP_MC_LCEGCHLC

NUS_HOGLBP_CTX_CLS_RESCORE_V2

False Positives - Motorbike

MITUCLA_HIERARCHY

NLPR_HOGLBP_MC_LCEGCHLC
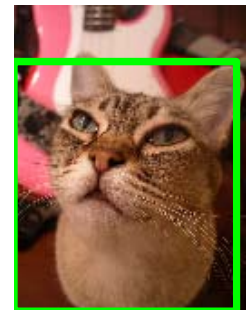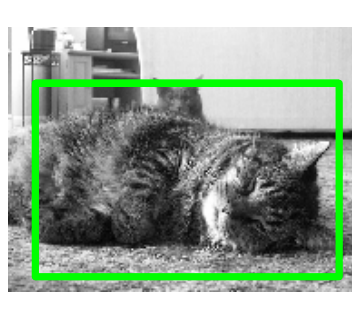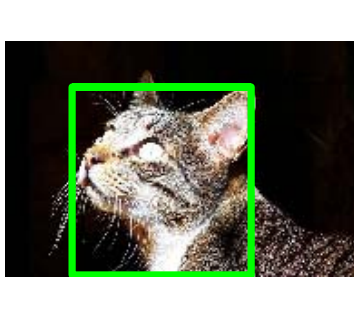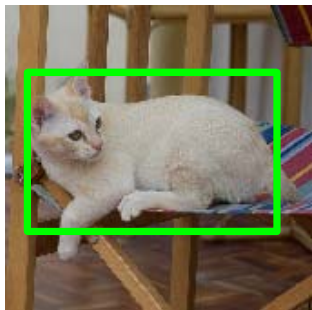

NUS_HOGLBP_CTX_CLS_RESCORE_V2
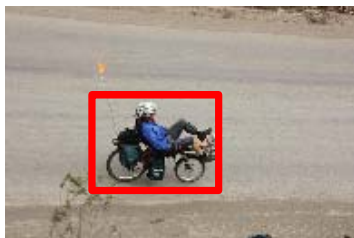
True Positives - Cat
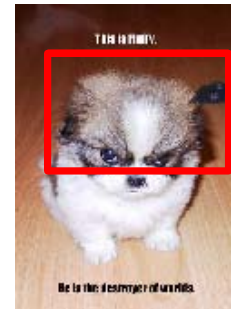
UVA_DETMONKEY

UVA_GROUPLOC
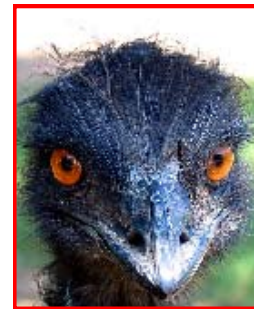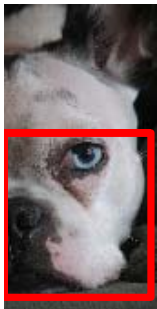
MITUCLA_HIERARCHY

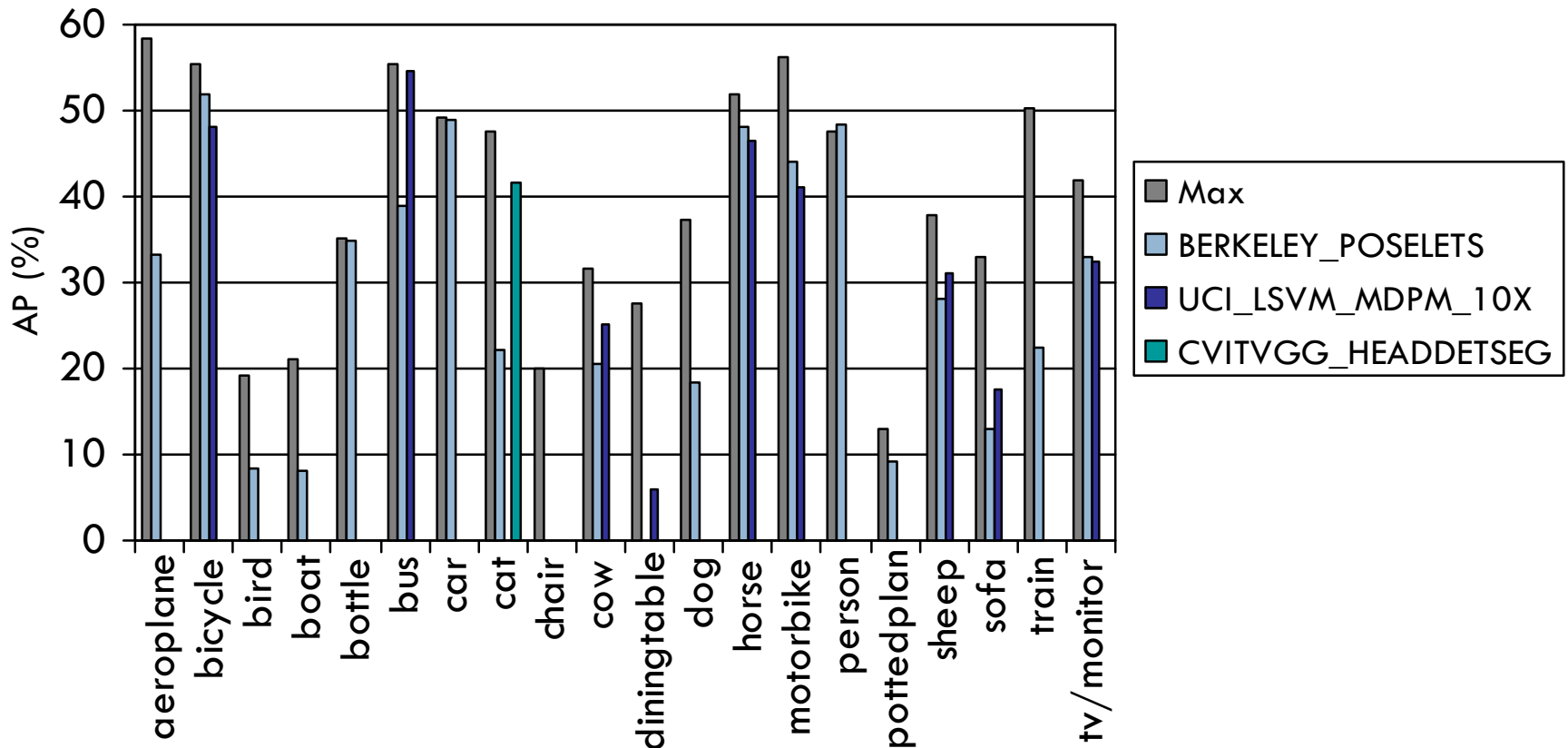# False Positives - Cat

UVA_DETMONKEY

UVA_GROUPLOC

MITUCLA HIERARCHY

Additional Training Data/Annotation

- BERKELEY use additional training data and annotation (manually labelled key points). Improves on best results for "person" class alone (1%).
- UCI annotated 10 times bigger training sets for some classes using Mechanical Turk. Does not improve on best results.
- CVIT/VGG used proprietary "cat" training set. Does not improve on best result.

Progress 2008-2010
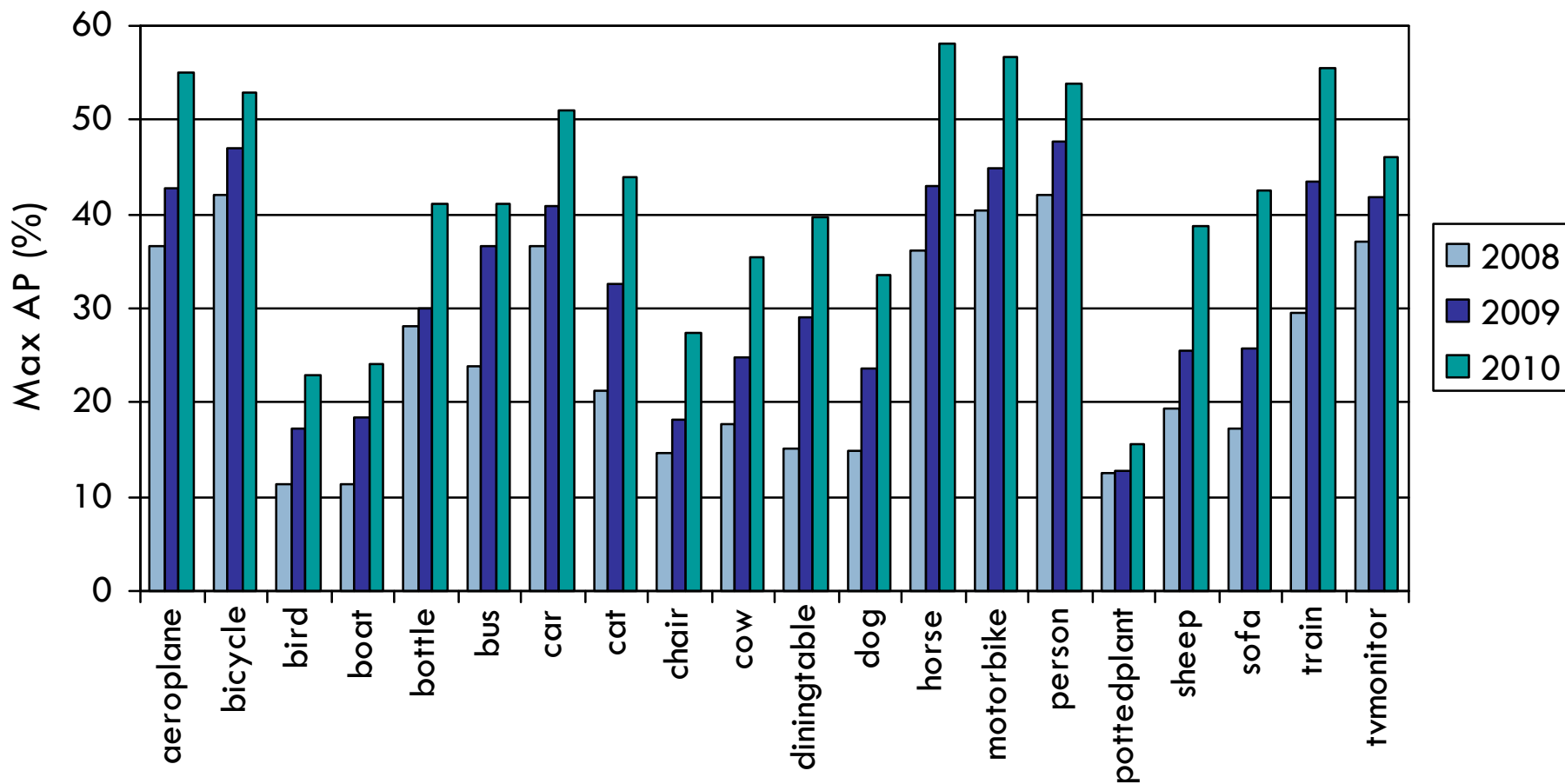
- **Results on 2008 data improve for best 2009 and 2010 methods for all categories, by over 100% for some categories**
  - Caveat: Better methods or more training data?

Progress 2009-2010
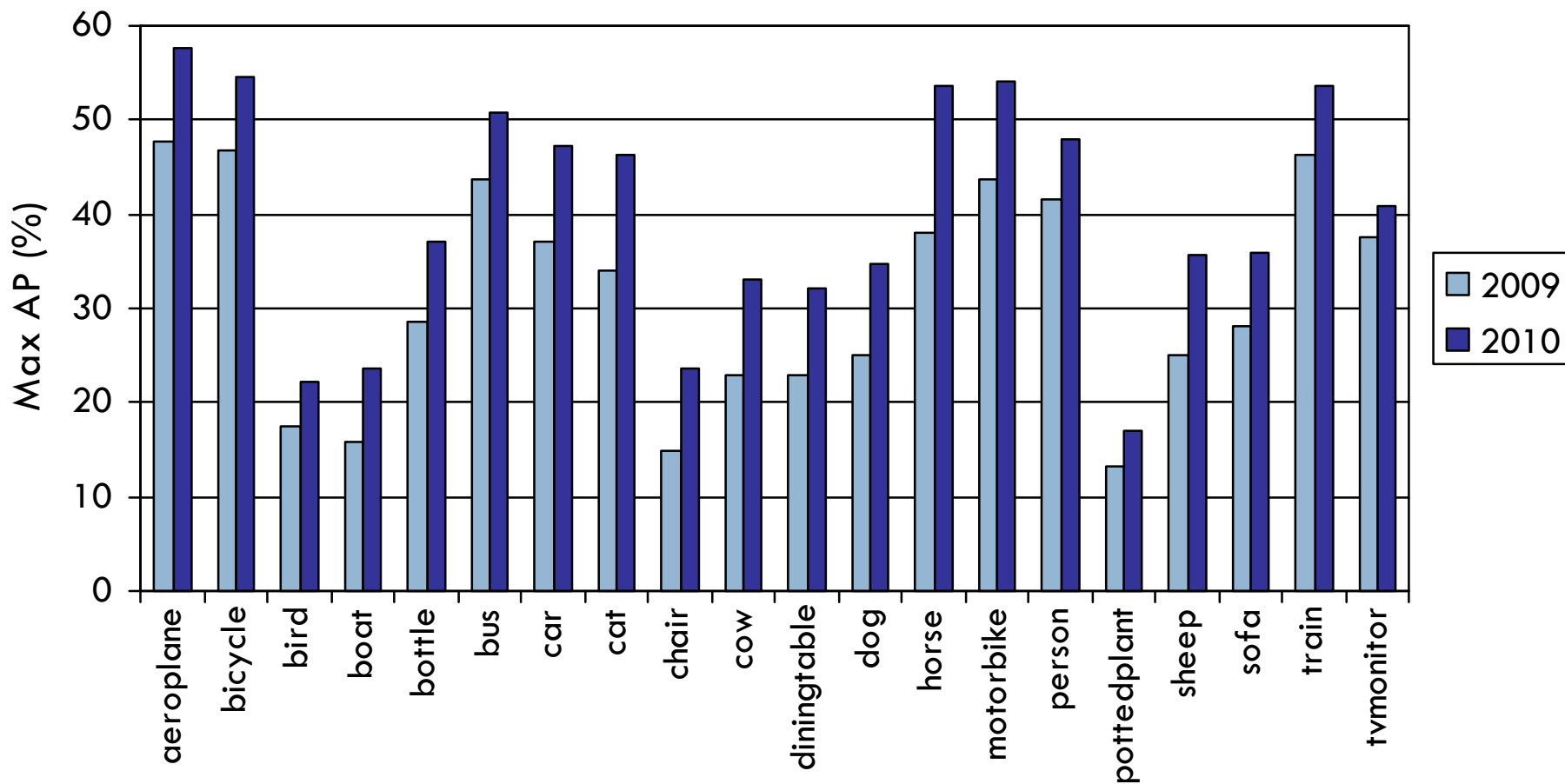
- **Best 2010 methods improve on 2009 results for all categories**
  - Caveat: Better methods or more training data?

Prizes

- ## Winner:
  - **NLPR_HOGLBP_MC_LCEGCHLC**
    Yinan Yu, Junge Zhang, Yongzhen Huang, Shuai Zheng, Weiqiang Ren, Chong Wang, Kaiqi Huang, Tieniu Tan
    National Laboratory of Pattern Recognition, Institute of Automation, Chinese Academy of Sciences

- ## Honourable Mentions:
  - **MITUCLA_HIERARCHY**
    Long Zhu, Yuanhao Chen, William Freeman, Alan Yuille, Antonio Torralba
    MIT, UCLA
  - **NUS_HOGLBP_CTX_CLS_RESCORE_V2**
    Zheng Song, Qiang Chen, Shuicheng Yan
    National University of Singapore
  - **UVA_GROUPLOC/UVA_DETMONKEY**
    Jasper Uijlings, Koen van de Sande, Theo Gevers, Arnold Smeulders, Remko Scha
    University of Amsterdam

"Lifetime Achievement" Prize

- **UoC/TTI Chicago**
  Pedro Felzenszwalb[1], Ross Girshick[1],
  David McAllester[2], Deva Ramanan[3]
  [1]University of Chicago
  [2]Toyota Technological Institute at Chicago
  [3]University of California, Irvine

- First submitted to the PASCAL VOC challenge in 2007, this detector has now become a core component of many classification, segmentation, person layout and action classification submissions

- We honour the contribution made to the community by the innovation and success of the method and its free distribution