The PASCAL Visual Object Classes Challenge 2011 (VOC2011)

Part 3 – Segmentation Challenge

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Luc Van Gool
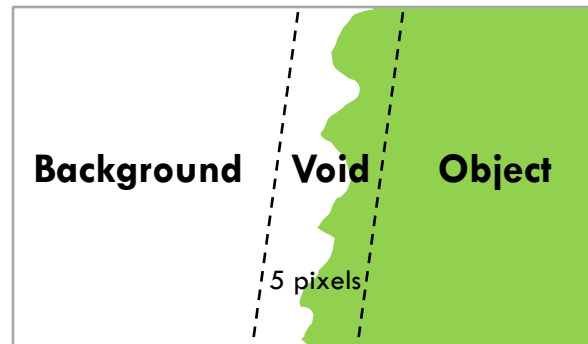
Chris Williams

John Winn

Andrew Zisserman

Segmentation Challenge

- For each pixel, predict the class of the object containing that pixel or 'background'.

- Competition 5: Train on the supplied data
  - Which methods perform best given specified training data?
  - Can use bounding box data as well as seg. data
- Competition 6: Train on any (non-test) data
  - Available since VOC2009
  - Allows for use of own data

Annotation

- Annotation in one session with <u>written guidelines</u>

  - Segmentation is 'refinement' of bounding box (but may go outside it)

  - Segmentation accurate to within 5-pixel boundary region which is marked 'void'

    Background   **Void**   **Object**

    5 pixels

  - 1-pixel wide structures (whiskers, wires) can be ignored

  - Surface objects considered part of the object (e.g. items on a table)
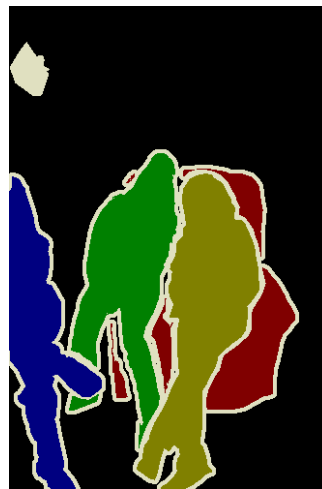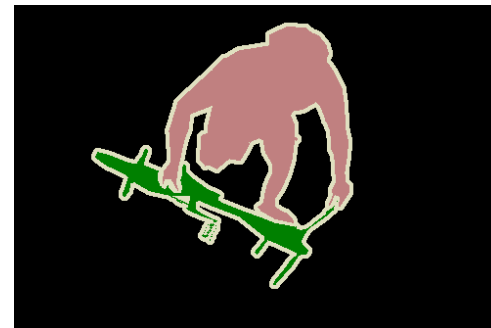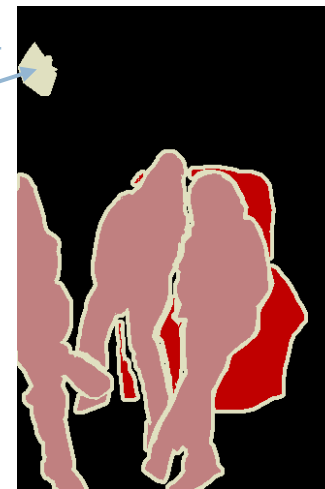
Example Annotations
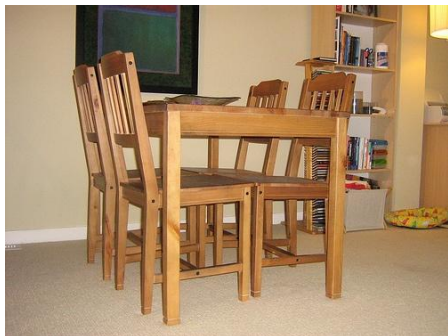
Image **Object segmentation** **Class segmentation**

Difficult objects masked
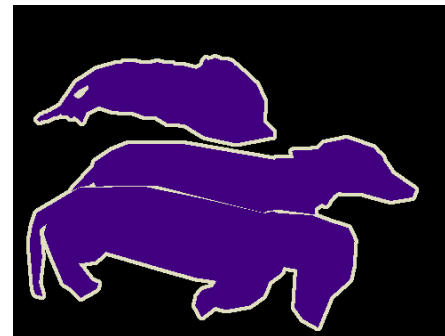
Example Annotations

Image	Object segmentation	Class segmentation

Dataset Statistics

- Contains VOC2008-10 data as subsets

- Around 20% increase in size over VOC2010

	Training		Testing	
Images	2,223	(1,928)	1,111	(964)
Objects	5,034	(4,203)	2,028	(1,663)

VOC2010 counts shown in brackets

- Over 2,000 training and1,000 test images

- Over 5,000 precisely segmented objects for training

Evaluation Metric

Intersection/union of **class** labels $= \dfrac{\text{true pos.class}}{\text{true pos.} + \text{false pos.} + \text{false neg.}}$

- Metric chosen because:
  - Allows per-class participation
  - Penalises both over- and under-estimates
- Overall evaluation metric is average over all classes (including background)

Methods

- 6 direct and 8 "automatic" entries

- Methods

  - Multiple figure-ground segmentations
    - Object overlap prediction using Support Vector Regression

  - Hierarchical CRFs, higher order cliques
    - Joint segmentation and detection

  - Low level segmentation + region classification
    - Ultrametric contour maps

  - Refinement of object detections
    - Learnt segmentation masks for part-based models
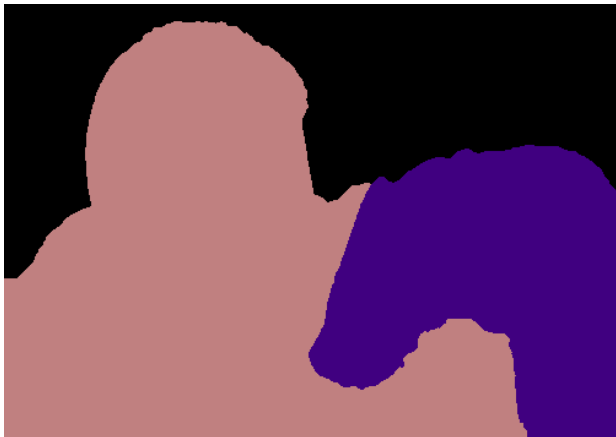
Example Segmentations

Image

Ground truth

BERKELEY_REGION_CLASSIFY

BROOKES_STRUCT_DET_CRT

BONN_SVR_SEGM

NUS_SEG_DET_MASK_CLS_CRF

Example Segmentations

Image   Ground truth   BERKELEY_REGION_CLASSIFY

BROOKES_STRUCT_DET_CRT   BONN_SVR_SEGM   NUS_SEG_DET_MASK_CLS_CRF
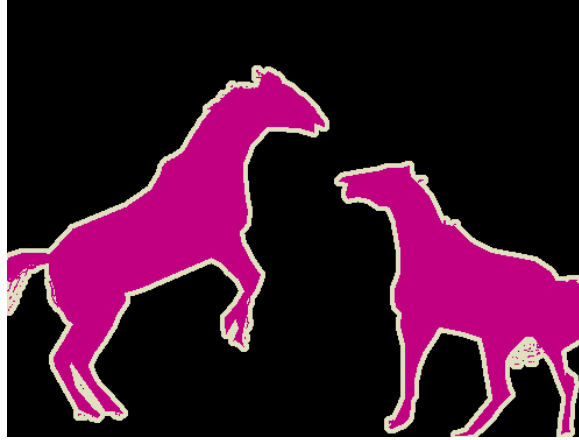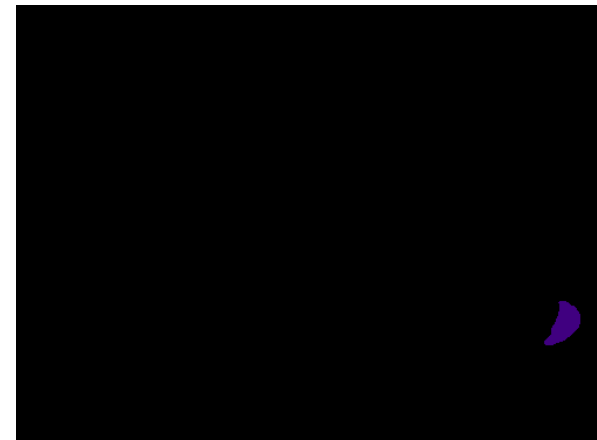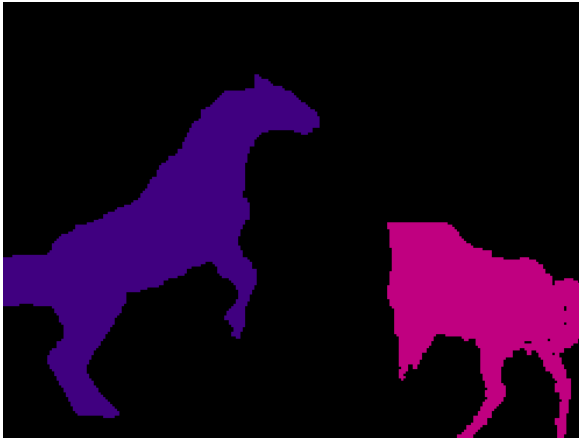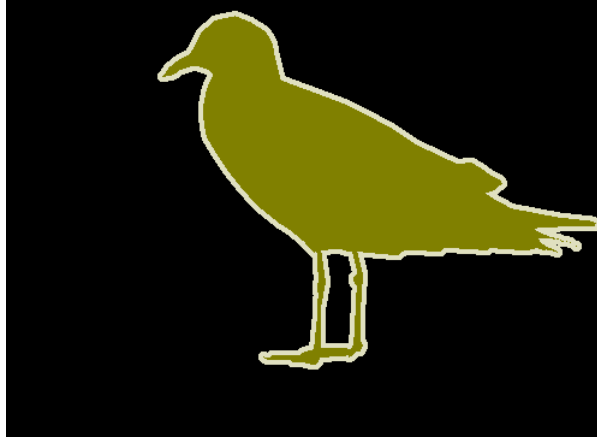
Example Segmentations
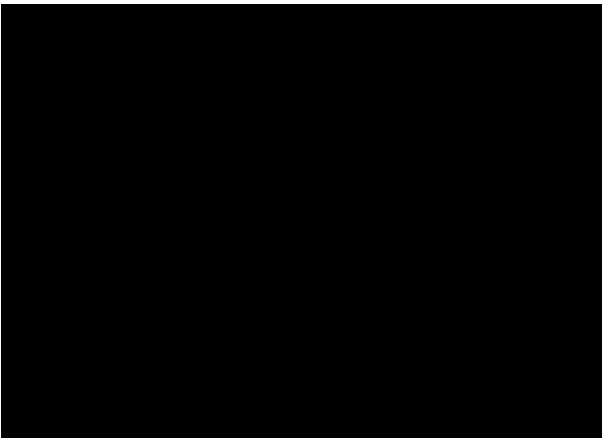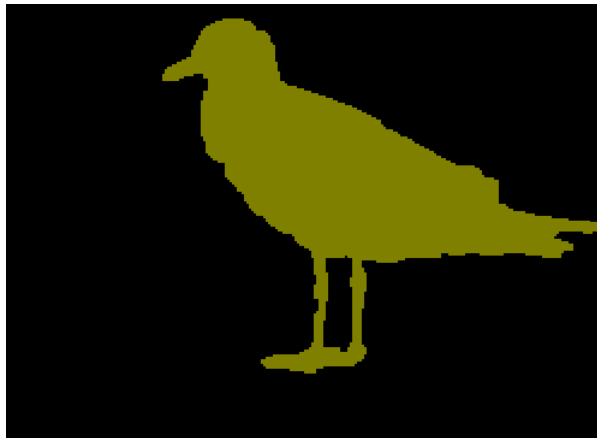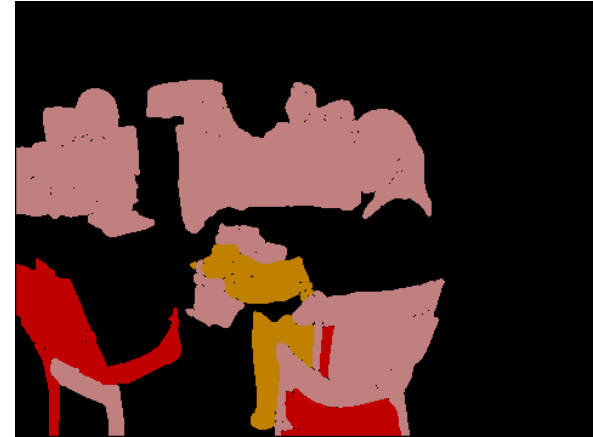
Example Segmentations

Image

Ground truth

BERKELEY_REGION_CLASSIFY

BROOKES_STRUCT_DET_CRT

BONN_SVR_SEGM

NUS_SEG_DET_MASK_CLS_CRF

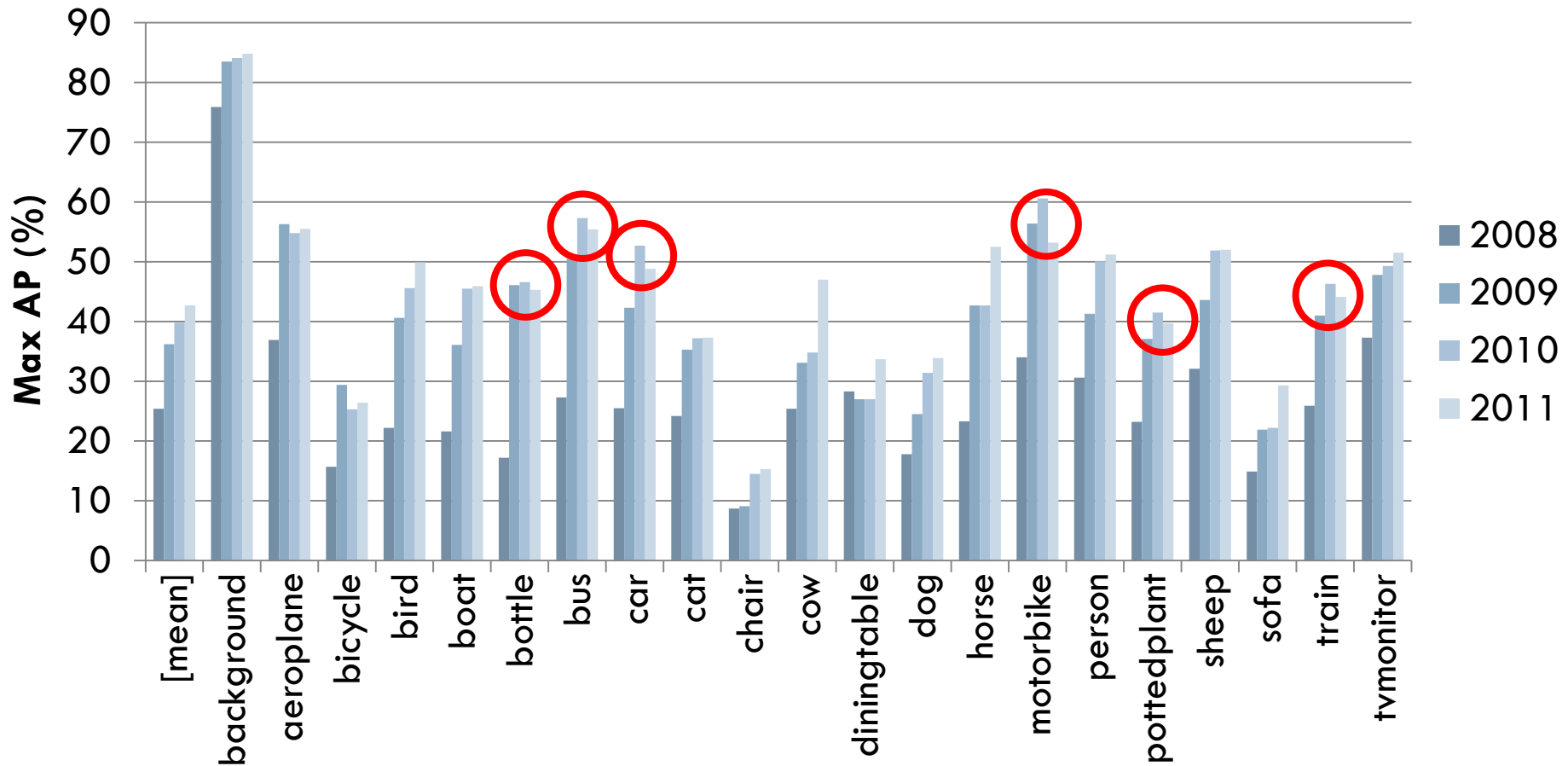# Accuracy by Class/Method (1st, 2nd, 3rd place)

Trained on VOC2011 data

	[mean]	back ground	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	41.4	83.4	51.7	23.7	46.0	33.9	49.4	66.2	56.2	41.7	10.4	41.9	29.6	24.4	49.1	50.5	39.6	19.9	44.9	26.1	40.0	41.6
BONN_SVR_SEGM	43.3	84.9	54.3	23.9	39.5	35.3	42.6	65.4	53.5	46.1	15.0	47.4	30.1	33.9	48.8	54.4	46.4	28.8	51.3	26.2	44.9	37.2
BROOKES_STRUCT _DET_CRT	31.3	79.4	36.6	18.6	9.2	11.0	29.8	59.0	50.3	25.5	11.8	29.0	24.8	16.0	29.1	47.9	41.9	16.1	34.0	11.6	43.3	31.7
NUS_CONTEXT_SVM	35.1	77.2	40.5	19.0	28.4	27.8	40.7	56.4	45.0	33.1	7.2	37.4	17.4	26.8	33.7	46.6	40.6	23.3	33.4	23.9	41.2	38.6
NUS_SEG_DET_MASK _CLS_CRF	37.7	79.8	41.5	20.2	30.4	29.1	47.4	61.2	47.7	35.0	8.5	38.3	14.5	28.6	36.5	47.8	42.5	28.5	37.8	26.4	43.5	45.8

Trained on external data

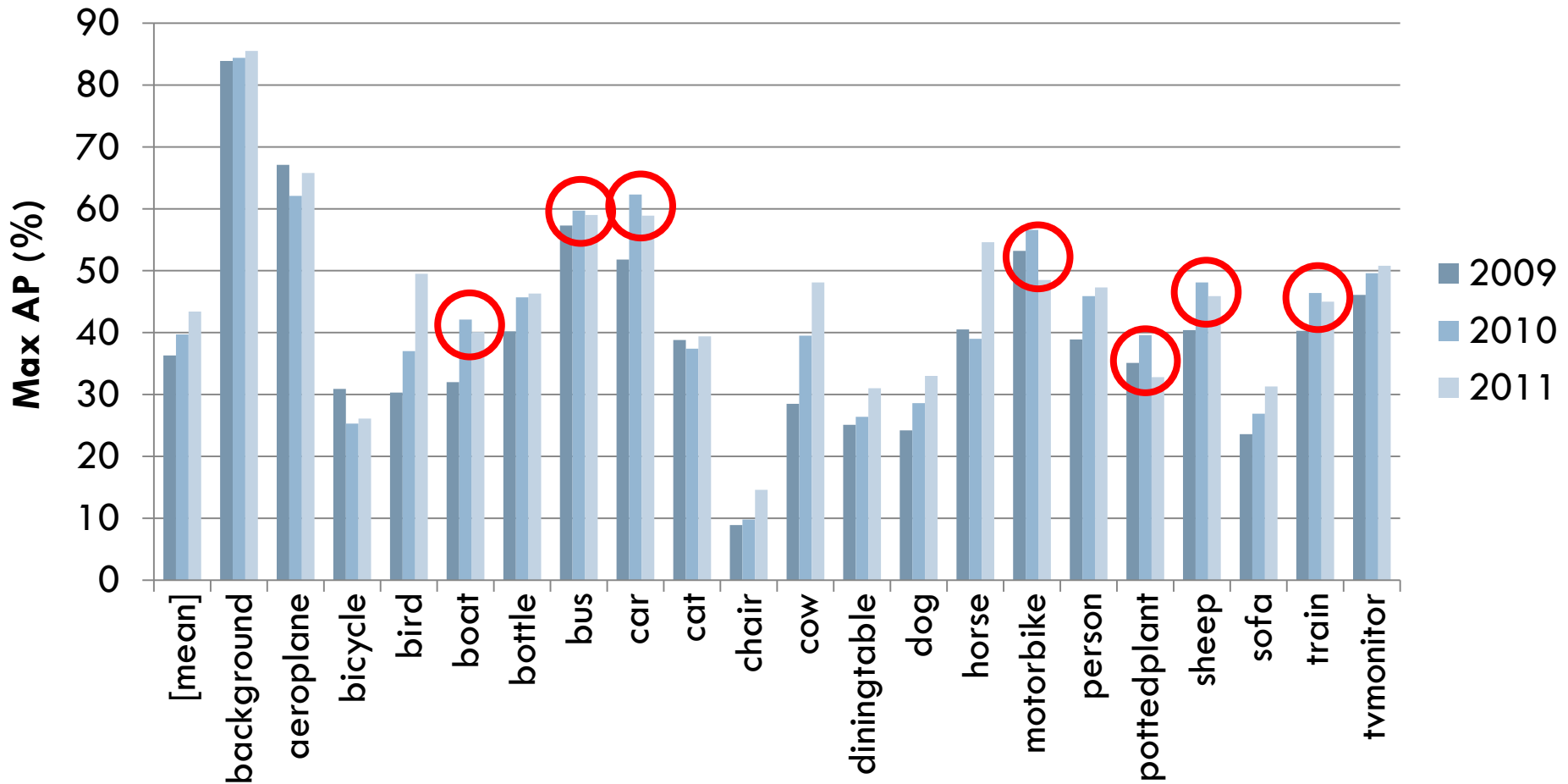|	[mean]	back ground	aero plane	bicycle	bird	boat	bottle	bus	car	cat	chair	cow	dining table	dog	horse	motor bike	person	potted plant	sheep	sofa	train	tv/ monitor
BERKELEY_REGION _CLASSIFY	39.1	83.3	48.9	20.0	32.8	28.2	41.1	53.9	48.3	48.0	6.0	34.9	27.5	35.0	47.2	47.3	48.4	20.6	52.7	25.0	36.6	35.4

- Best results exceed best detection-based results for all classes
- BONN_SVR_SEGM: 1st in 11 categories, 2nd in 9 categories
- BERKELEY_REGION_CLASSIFY: 1st in 4 categories using own data
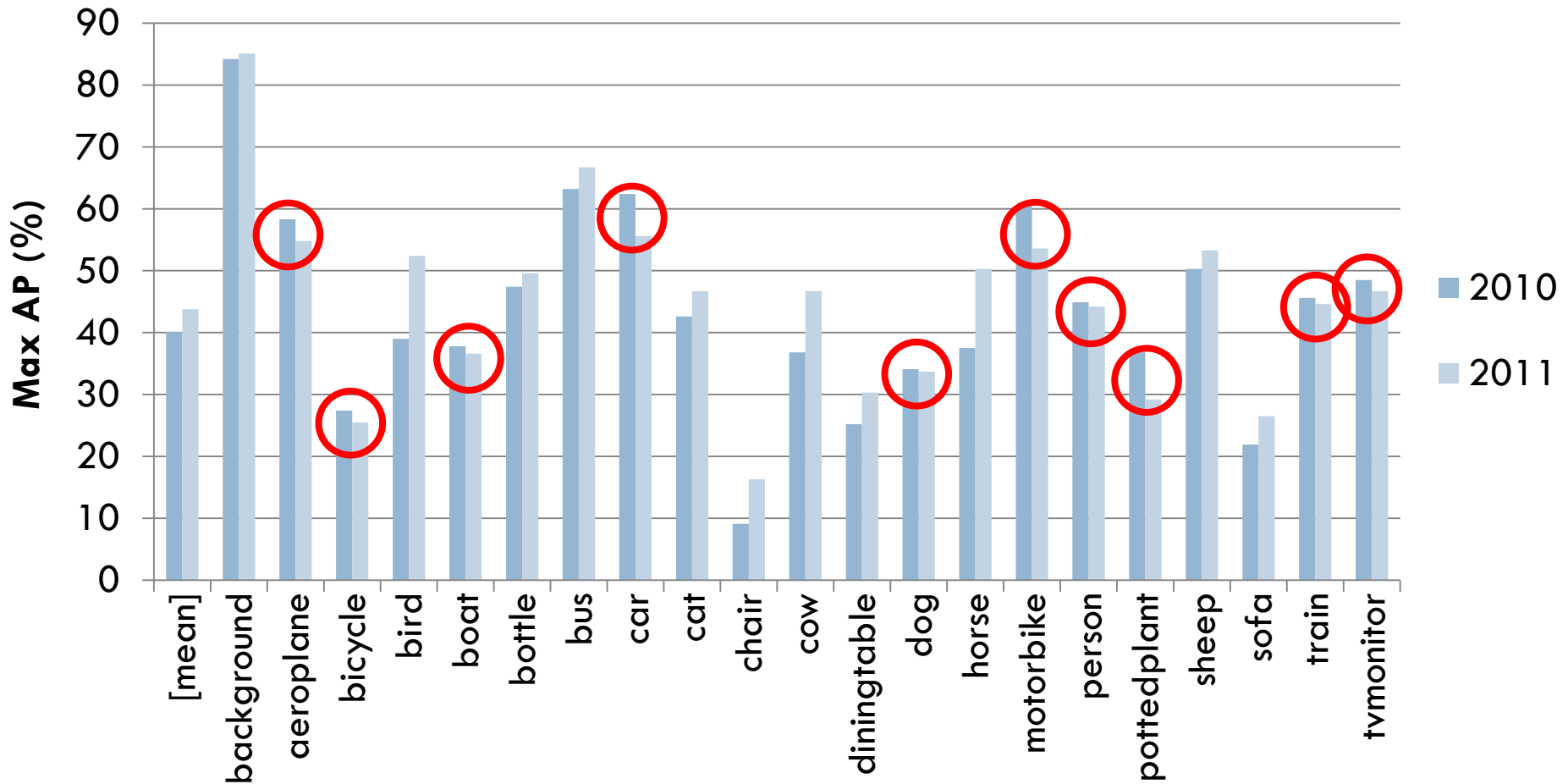
Progress 2008-2010

- **Results on 2008 data improve for best methods 2009-2011 for mean and most categories**
  - Caveats: More training data + re-use of test data

Progress 2009-2011

- Results on 2009 data improve for best methods 2010-2011 for mean and most categories
  - Caveats: More training data + re-use of test data

Progress 2010-2011

- Results on 2010 data improve for best 2011 methods for mean and 11/21 categories
  - Caveats: More training data + re-use of test data

Prizes

- Winner:
  - **BONN_SVR_SEGM/BONN_FGT_SEGM**
    João Carreira[1], Adrian Ion[2], Fuxin Li[3], Cristian Sminchisescu[1]
    [1]University of Bonn,
    [2]Vienna University of Technology,
    [3]Georgia Institute of Technology

- Honourable Mention:
  - **BERKELEY_REGION_CLASSIFY**
    Pablo Arbelaez, Bharath Hariharan, Saurabh Gupta, Chunhui Gu, Lubomir Bourdev and Jitendra Malik
    University of California, Berkeley