Subcategory-aware Convolutional Neural Networks for Object Proposals and Detection

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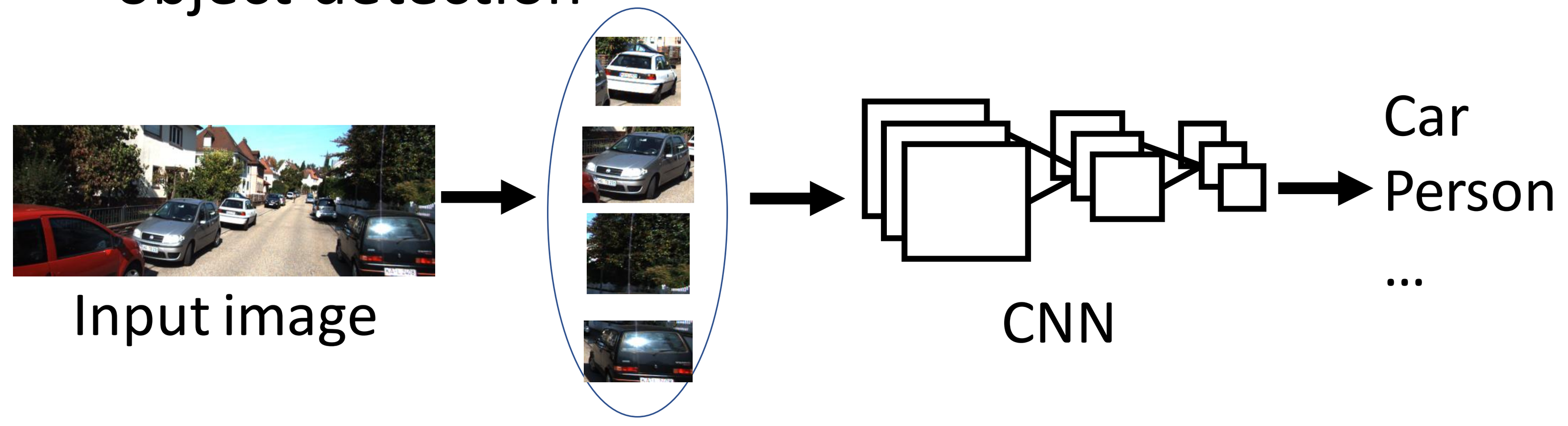
Introduction

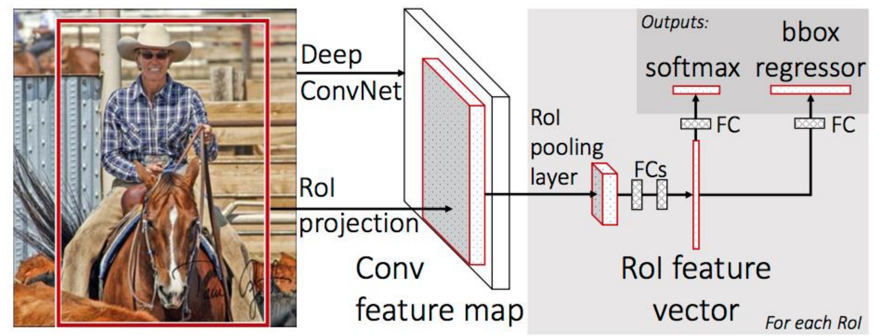
- Convolutional Neural Network (CNN) for object detection



- How to handle large scale change, occlusion and truncation?
- How to estimate detailed properties of objects (3D pose, 3D shape, 3D location)?
- We use subcategory information to help object proposal and detection in this work.

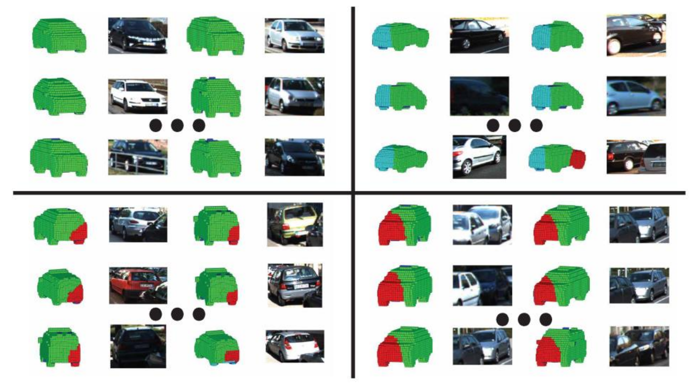
Related Work

- CNN-based object detection



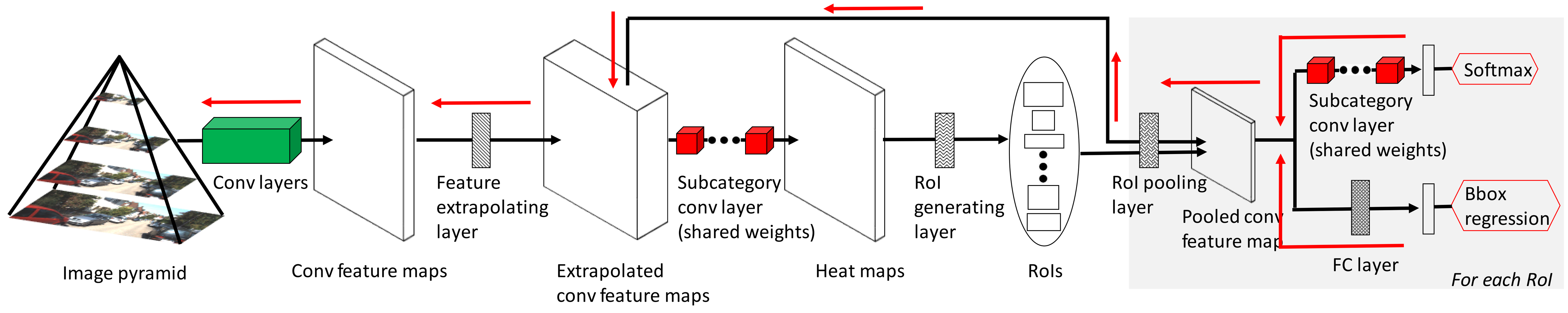
Fast RCNN. R. Girshick., ICCV'15.
Faster RCNN. Ren et al., NIPS'15.
YOLO. Redmon, et al., CVPR'16.
SSD. Liu et al., ECCV'16.

- Subcategory in object detection

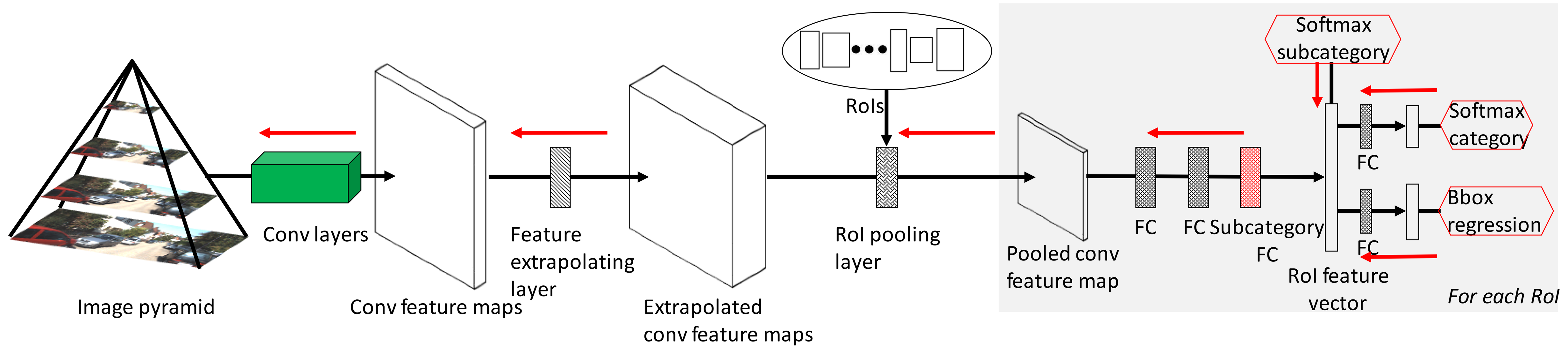


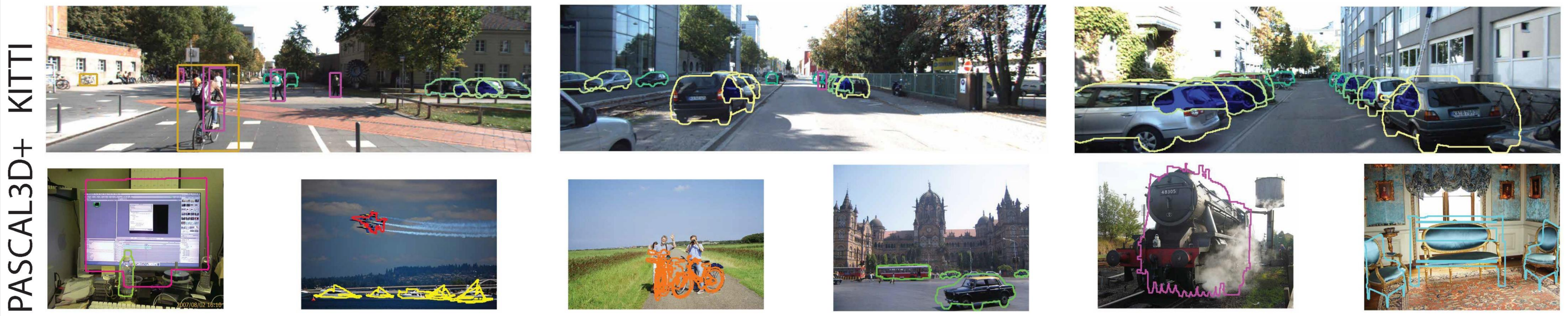
DPM. Felzenszwalb et al., TPAMI'10.
Gu & Ren, ECCV'10.
Ohn-Bar & Trivedi, ITS'15.
3DVP. Xiang et al., CVPR'15.

Subcategory-aware Region Proposal Network



Subcategory-aware Detection Network





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Experiments

- Region proposal performance on KITTI [16]

Method	Easy	Moderate	Hard	Easy	Moderate	Hard	Easy	Moderate	Hard
	Car			Pedestrian			Cyclist		
SelectiveSearch [1]	58.17	42.12	37.62	68.95	57.65	52.57	57.05	49.59	49.44
EdgeBoxes [2]	81.40	61.84	55.68	86.15	71.88	65.39	56.11	46.52	45.72
RPN [3]	98.84	**97.37**	**95.31**	98.88	91.69	88.64	96.55	91.80	89.41
SubCNN	**99.27**	96.28	93.14	**99.44**	**93.46**	**91.02**	**99.67**	**93.03**	**91.64**

- Detection and Orientation Estimation on KITTI car

	Object Detection (AP)			Orientation Estimation (AOS)		
Method	Easy	Moderate	Hard	Easy	Moderate	Hard
ACF [4]	55.89	54.74	42.98	N/A	N/A	N/A
DPM [5]	68.02	56.48	44.18	67.27	55.77	43.59
DPM-VOC+VP [6]	74.59	64.71	48.76	72.28	61.84	46.54
OC-DPM [7]	74.94	65.95	53.86	73.50	64.42	52.40
SubCat [8]	84.14	75.46	59.71	83.41	74.42	58.83
Regionlets [9]	84.75	76.45	59.70	N/A	N/A	N/A
AOG [10]	84.80	75.94	60.70	33.79	30.77	24.75
Faster R-CNN [3]	86.71	81.84	71.12	N/A	N/A	N/A
3DVP [11]	87.46	75.77	65.38	86.92	74.59	64.11
3DOP [12]	**93.04**	88.64	79.10	**91.44**	86.10	76.52
Mono3D [13]	92.33	88.66	78.96	91.01	86.62	76.84
SDP+RPN [14]	90.14	88.85	78.38	N/A	N/A	N/A
MS-CNN [15]	90.03	89.02	76.11	N/A	N/A	N/A
SubCNN-VGG16	90.74	88.55	77.95	90.49	87.88	77.10
SubCNN-GoogleNet	90.81	**89.04**	**79.27**	90.67	**88.62**	**78.68**

- Detection and Pose Estimation on PASCAL3D+ [17]

Method	DPM [5]	DPM-VOC+VP [6]	Ours w/o extra	Ours Full
Detection AP	29.6	28.3	58.8	**60.7**
Pose 4 views AVP	19.5	24.5	45.2	**47.5**
Pose 8 views AVP	18.7	22.2	28.6	**31.9**
Pose 16 views AVP	15.6	17.9	22.3	**24.5**
Pose 24 views AVP	12.1	14.4	17.9	**19.3**