Multi-stage Deep Convolutional Neural Network For Generic Object Detection

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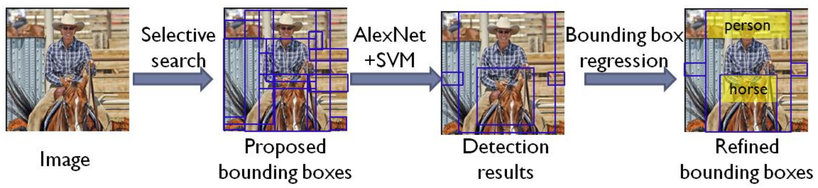
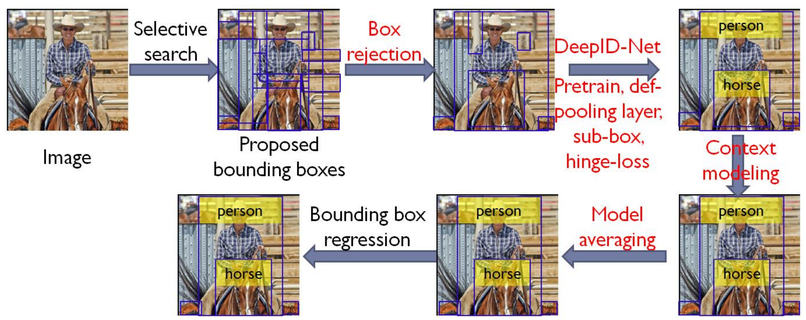
RCNN [1]:



Our approach[3]:



Contribution:

1. Diagram for generic object recognition with deep learning
2. Bounding box rejection (1%)
3. DeepID-Net
   - ➢ Strategies of pre-training features with classification data (4%)
   - ➢ Def-pooling Layer (1.5%)
   - ➢ Sub-box detector (0.5%)
   - ➢ Hinge-loss
4. Context Modeling (0.8%~1%)
5. Model Averaging (5%)

◆ Bounding Box Rejection:

Motivation:

1. Speed up feature extraction by ~10 times
2. Improve mean AP by 1%

RCNN:

- ➢ Selective search: 2400 bounding boxes per image
- ➢ 38 hours for extracting features from 10,000 images
- ➢ ILSVRC13 val: ~20,000 images, ~ 2.4 days
- ➢ ILSVRC 13 test: ~ 40,000 images, ~4.7 days

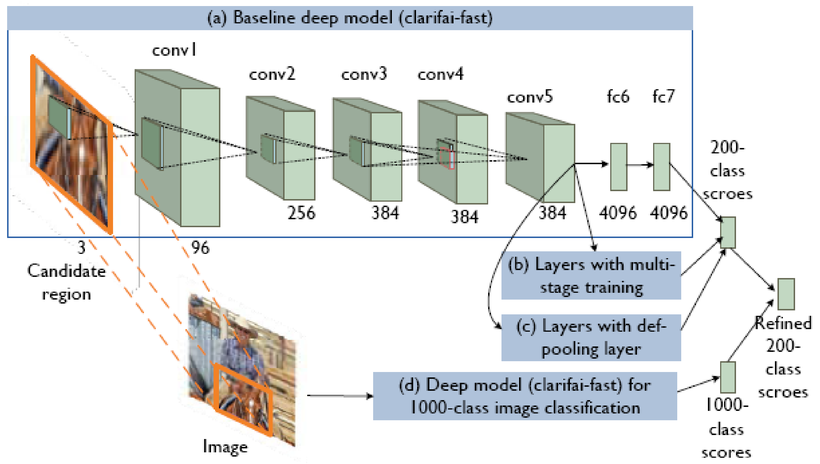
Reject bounding boxes from RCNN:

- ➢ For each bounding box, RCNN provides 200 scores for 200 classes
- ➢ If $\max(S_{1,\ldots,200}) < -1.1$, 6% bounding boxes remains.

Remaining Window	100%	20%	6%
Recall (val)	92.2%	89.0%	84.4%
Feature extraction time (seconds per image)	10.24	2.88	1.18
Mean AP on val2	0.299	-	0.309

1, Girshick, Ross. et al, Rich feature hierarchies for accurate object detection and semantic segmentation, CVPR 2014
2, Xingyu ZENG et al, Multi-stage contextual deep learning for pedestrian detection, ICCV 2013
3. Wanli ouyang, etal, DeepID-Net: multi-stage and deformable deep convolutional neural network for generic object detection, arXiv

◆DeepID-Net2:



➢Strategies for Pre-training features with classification data:

- •Classification vs detection (image vs tight bounding box)
- •AlexNet, Clarifai or other choices
- •Complementarity
- •1000 classes vs 200 classes

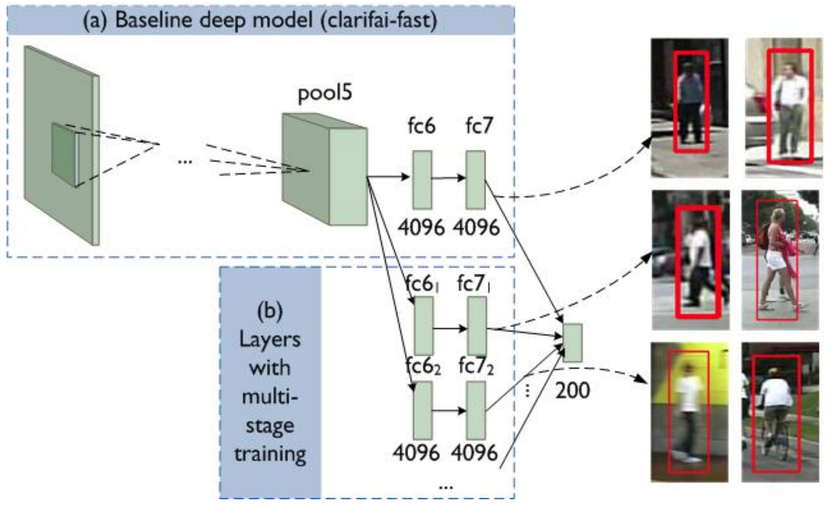
Training Scheme	Cls+Det	Cls+Det	Cls+Loc+Det	Loc+Det
Net Structure	AlexNet	Clarifai	Clarifai	Clarifai
Mean AP(val2)	0.309	0.318	0.334	0.360

Cls (Loc) means pre-training with images (localized objects) from classification dataset

Det means fine tuning with the detection dataset

➢Multi-Stage fully connected layers training [2]

- •Multi-classifiers trained jointly and sequentially
- •Each fully connected layers can be regarded as one classifier
- •Each fully connected layers branch handles different samples in different difficulty levels.



➢Multi-Stage fully connected layers training (continue …)

Algorithm 1: Stage-by-Stage Training

Input: Training set: $\Psi = \{\mathbf{s}_0, \mathbf{f}\}$
Parameters Θ for the baseline deep model obtained by pretraining.

Output: Parameters Θ for the baseline deep model, Parameters $\mathbf{W}_{l,t}, l = 6, 7, 8t = 1, \cdots, T$ for the extra layers.

1 Set elements in $\mathbf{W}_{l,t}$ to be 0;
2 BP to fine-tune Θ, while keeping $\mathbf{W}_{l,t}$ as 0;
3 **for** *t=1 to T* **do**
4 Use BP to update parameters $\mathbf{W}_{l,t}, l = 6, 7, 8$ while fixing Θ and $\mathbf{W}_{l,1}, \cdots, \mathbf{W}_{l,t-1}$;
5 Use BP to update parameters Θ and $\mathbf{W}_{l,1}, \cdots, \mathbf{W}_{l,t}, l = 6, 7, 8$;
6 **end**
7 Output Θ and $\mathbf{W}_{l,t}, l = 6, 7, 8, t = 1, \cdots, T$.

Training scheme	Loc+Det	Loc+Det	Loc+Det
Net structure	Clarifai	Clarifai+1 multi-layers	Clarifai+2 multi-layers
Mean AP on val2	0.360	0.370	0.375

Each round of training will focus on misclassified training samples. Zero initialization makes correctly-classified samples little influence.

◆Model Averaging

➢Net Structure: Alex (A), Clarifai (C), Deep-ID Net (D), Deep-ID Net2(D2)

➢Pretrain Scheme: Classification (C), Localization (L)

➢Bounding box rejection or not

➢Loss of net, softmax-loss (S), Hinge-loss (H)

Model	1	2	3	4	5	6	7	8	9	10
Net structure	A	A	C	C	D	D	D2	D	D	D
Pretrain	C	C+L	C	C+L	C+L	C+L	L	L	L	L
Bbox rejection	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Loss of net	S	S	S	H	H	H	H	H	H	H
Mean AP	0.31	0.312	0.321	0.336	0.353	0.36	0.37	0.37	0.371	0.374

Pipeline	RCNN	Bbox rejection	Clarifai	Loc+Det	Multi-stage layer	context	regression	Model avg.
Mean AP (val2)	0.299	0.309	0.318	0.36	0.375	0.383	0.393	0.45