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Mix-and-Match Tuning for Self-Supervised Semantic Segmentation

Xiaohang Zhan, Ziwei Liu, Ping Luo, Xiaoou Tang, Chen Change Loy

Department of Information Engineering, The Chinese University of Hong Kong

{zx017, lz013, pluo, xtang, ccloy}@ie.cuhk.edu.hk

Self-supervised Learning

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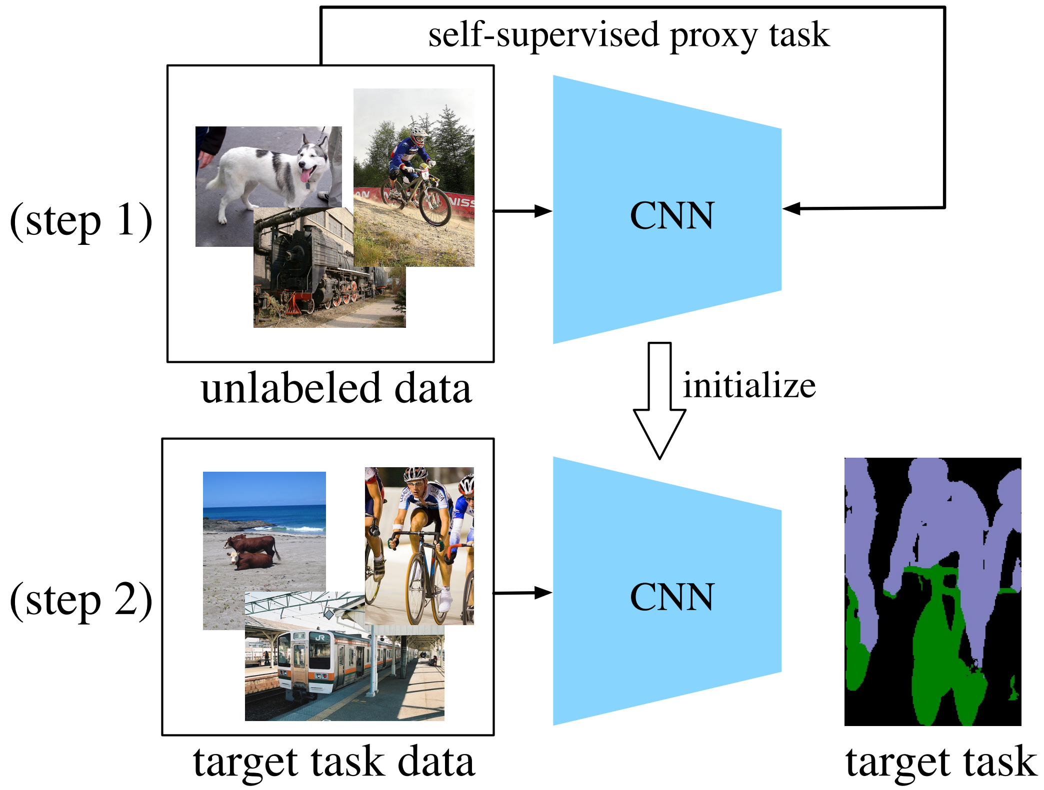
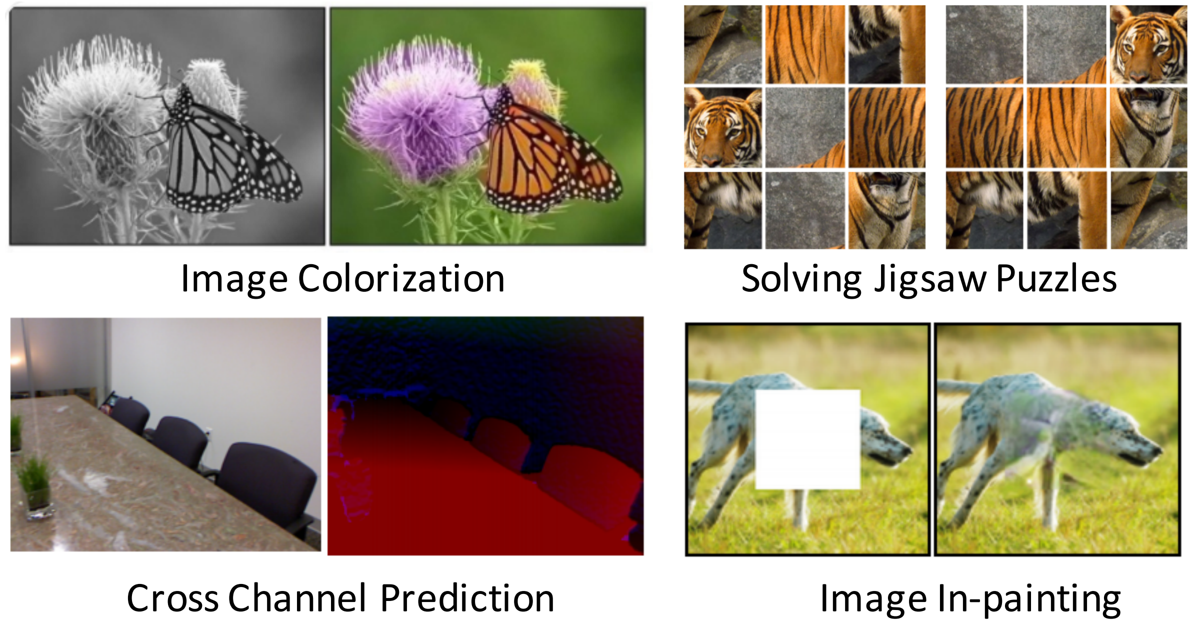


Self-supervised proxy task, e.g.:



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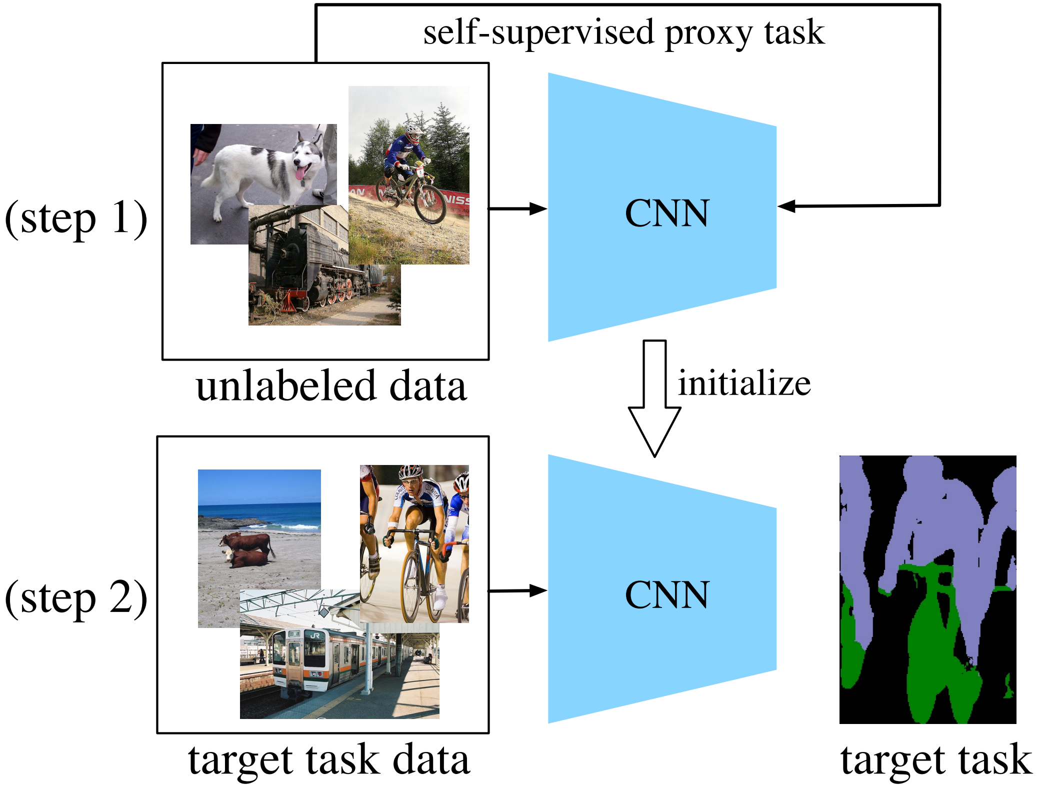


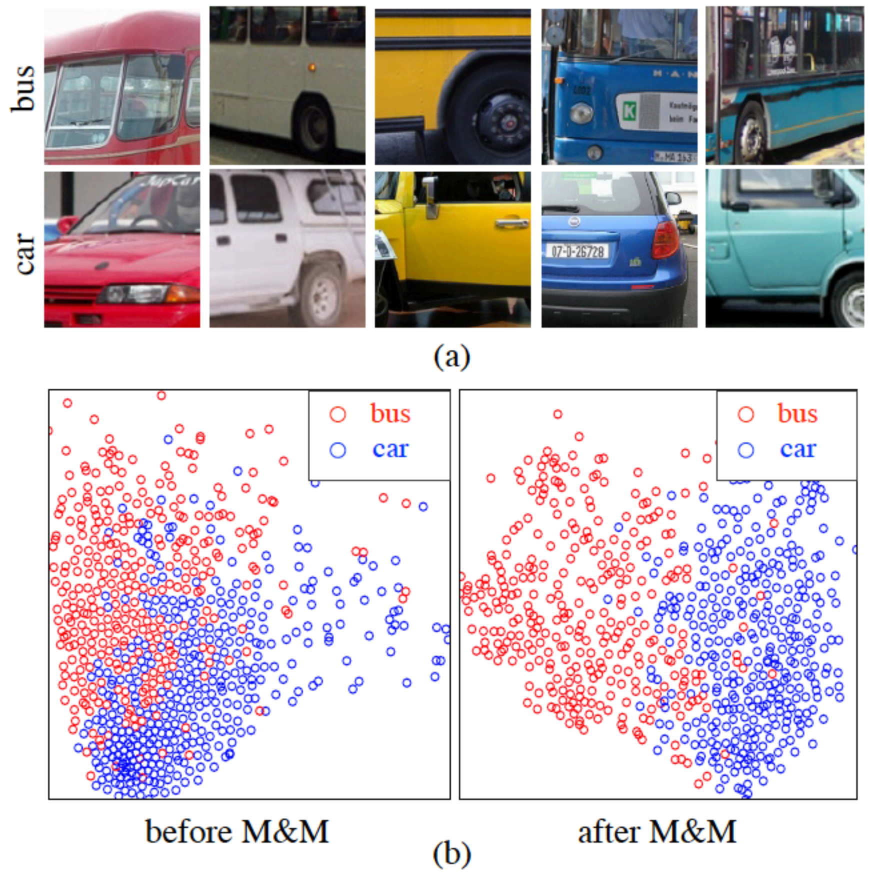
Method	Arch.	VOC12 %mIoU.
ImageNet	VGG-16	64.2
Random	VGG-16	35.0
Larsson *et al.* (Larsson, Maire, and Shakhnarovich 2016)	VGG-16	50.2
Larsson *et al.* (Larsson, Maire, and Shakhnarovich 2017)	VGG-16	56.0
Ours (M&M + Graph, colorization pre-trained)	VGG-16	**64.5**
ImageNet	AlexNet	48.0
Random	AlexNet	23.5
k-means (Krähenbühl et al. 2015)	AlexNet	32.6
Pathak *et al.* (Pathak et al. 2016b)	AlexNet	29.7
Donahue *et al.* (Donahue, Krähenbühl, and Darrell 2016)	AlexNet	35.2
Zhang *et al.* (Zhang, Isola, and Efros 2016a)	AlexNet	35.6
Zhang *et al.* (Zhang, Isola, and Efros 2016b)	AlexNet	36.0
Noroozi et al. (Noroozi and Favaro 2016)	AlexNet	37.6
Larsson *et al.* (Larsson, Maire, and Shakhnarovich 2017)	AlexNet	38.4
Ours (M&M + Random Triplets, colorization pre-trained)	AlexNet	40.9
Ours (M&M + Graph, colorization pre-trained)	AlexNet	42.8
Ours (M&M + Graph, randomly initialized)	AlexNet	**43.6**

8.2%

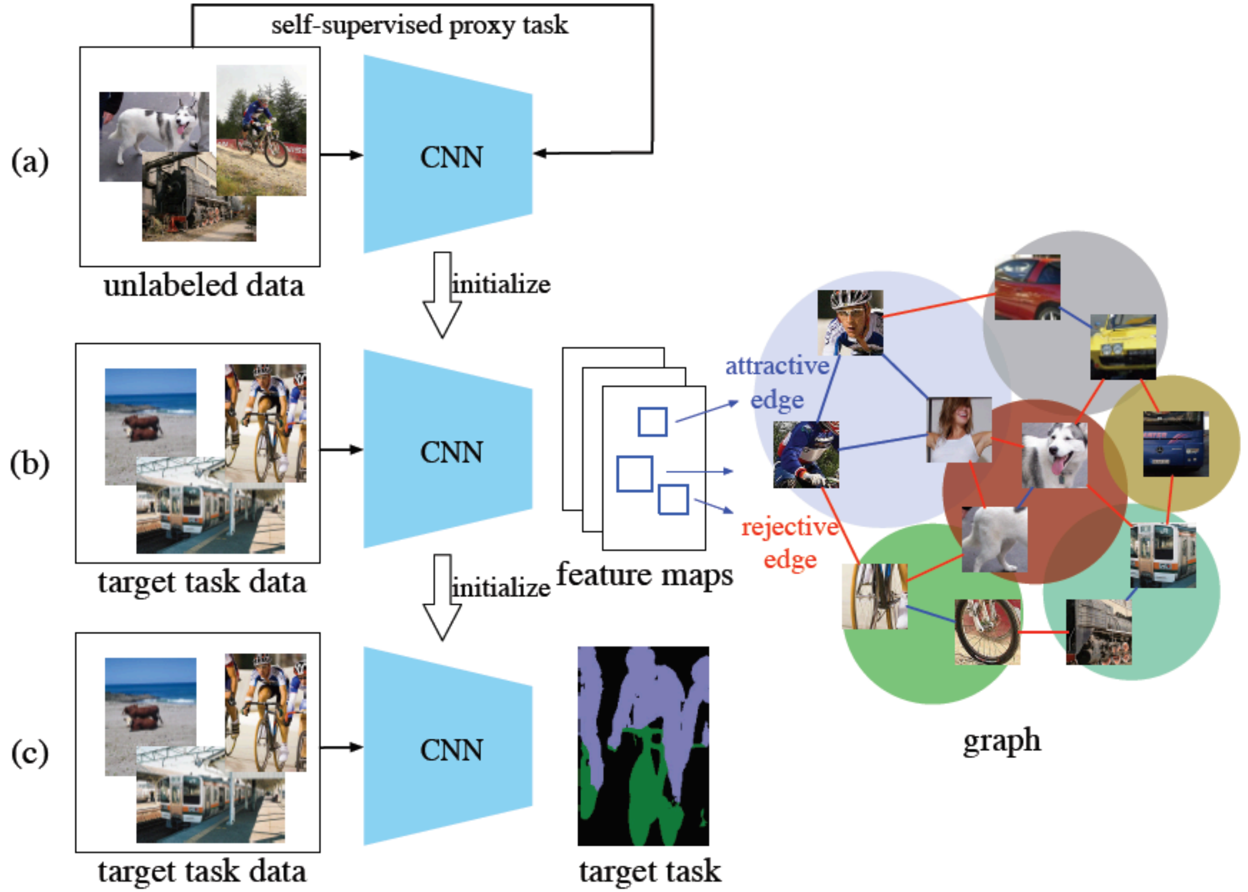
9.6%

Sematic Segmentation benchmark (PASCAL VOC 2012 validation set)

Task Gap



Self-supervised representations sensitive to the designed proxy task rather than the target task.



Mix-and-match tuning to narrow the gap.

Class-wise Connected Graph

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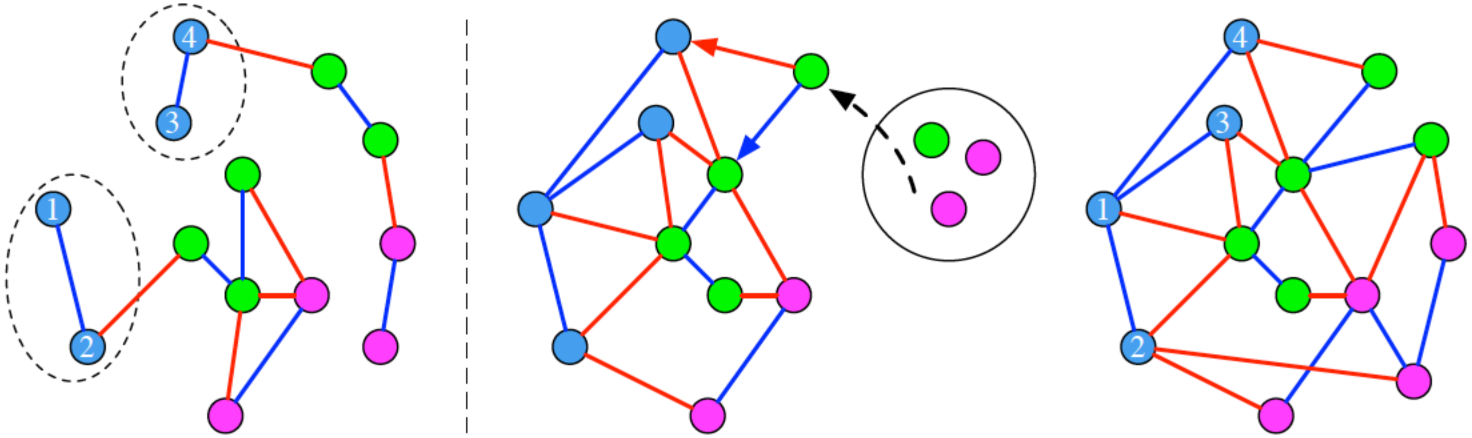

(a)
random triplets

(b-i)
construction of class-wise connected graph

(b-ii)
the final graph

(a) Randomly selected triplets
i. May form multiple centers for each class
ii. Some nodes will never be used

(b) Our class-wise connected graph:
i. All nodes within the same class form a connected graph
ii. Each node can serve as an "anchor" node and to be used for optimization.

Training

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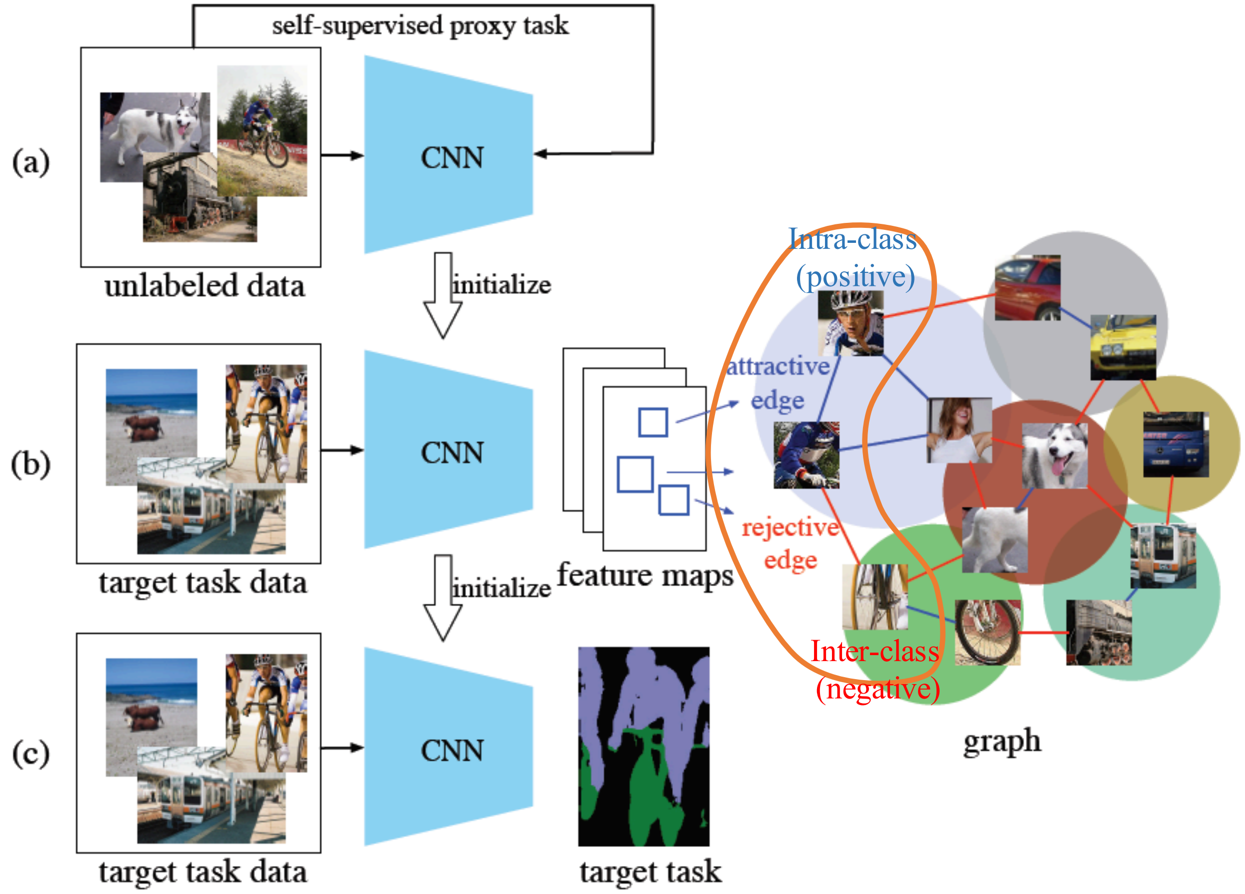

Formulate into triplet loss:

$$L = \frac{1}{N}\sum_{i}^{N} \max\left\{D\left(P_a^i, P_p^i\right) - D\left(P_a^i, P_n^i\right) + \alpha, 0\right\},$$

$$D(P_i, P_j) = \|(\mathbf{x}_i/\|\mathbf{x}_i\|_2 - \mathbf{x}_j/\|\mathbf{x}_j\|_2)\|^2,$$

For each node as an anchor (P_a), and randomly selected positive (P_p), randomly selected negative (P_n).
X_i : CNN representation on node i

Experiments

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PASCAL VOC 2012 validation set

Experiments

benchmark	PASCAL VOC2012					CityScapes	
pre-train	Random	Jigsaw	Colorize	Random	Colorize	Random	Colorize
backbone	AlexNet			VGG-16		VGG-16	
baseline	19.8	36.5	38.4	35.0	60.2	42.5	57.5
M&M	**43.6**	41.2	42.8	56.7	**64.5 (64.3)**	49.1	**66.4 (65.6)**
ImageNet	48.0			64.2		67.9	

Full results with different baselines and datasets

Experiments

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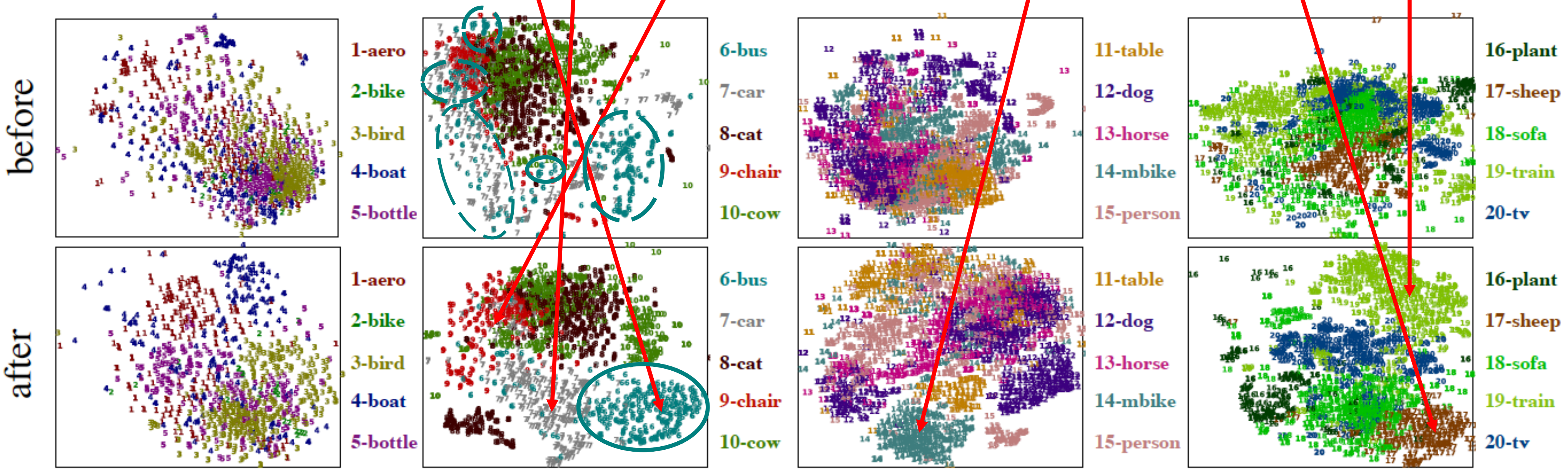
	aero	bike	bird	boat	bottle	bus	car	cat	chair	cow	table	dog	horse	mbike	person	plant	sheep	sofa	train	tv	mIoU.
ImageNet	81.7	**37.4**	**73.3**	55.8	59.6	82.4	74.7	82.4	30.8	60.3	46.1	**71.4**	65.3	**72.6**	76.7	**49.7**	70.6	34.2	72.7	**60.2**	64.2
Colorization	73.6	28.5	67.5	55.5	50.2	78.3	66.1	78.3	26.8	60.8	**50.6**	70.6	64.9	62.2	73.5	38.2	66.8	**38.8**	68.1	55.1	60.2
M&M	**83.1**	37.0	69.6	**56.1**	**62.9**	**84.4**	**76.4**	**82.8**	**33.4**	**61.5**	44.7	67.3	**68.5**	68.0	**78.5**	42.2	**72.7**	37.2	**75.7**	58.6	**64.5**
Ensemble ImageNet+M&M	84.5	39.4	76.3	60.3	64.6	85.4	77.7	84.1	35.6	63.6	50.4	70.6	72.0	73.6	80.1	50.2	73.7	37.6	77.8	66.6	67.4



Per-class results and T-SNE feature visualization

Experiments

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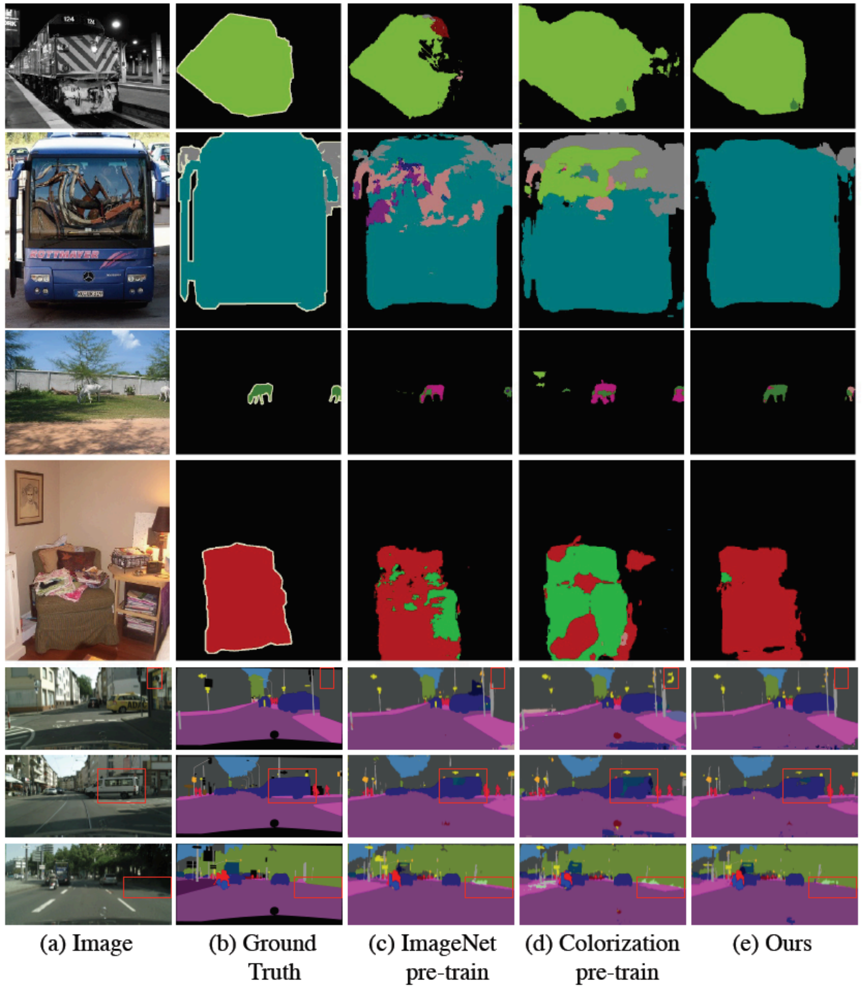
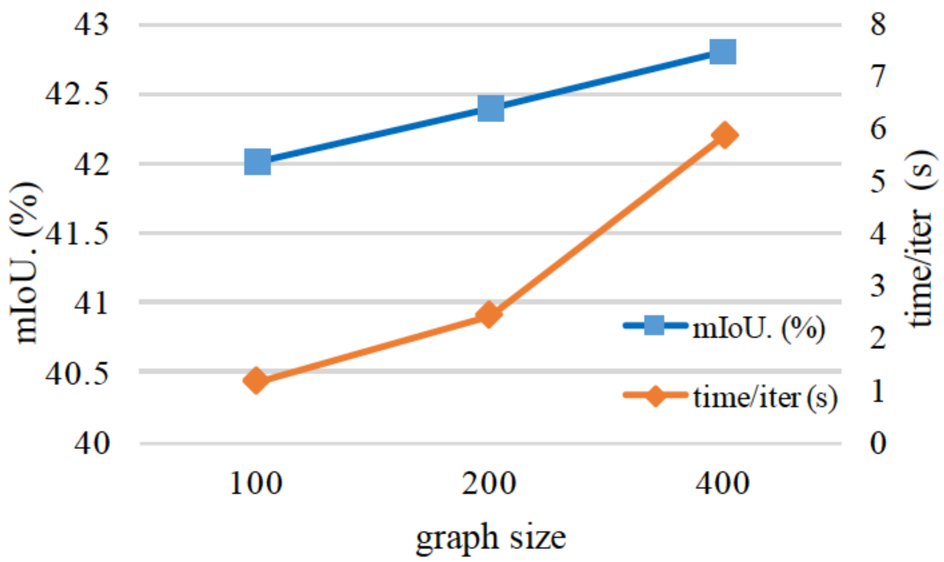
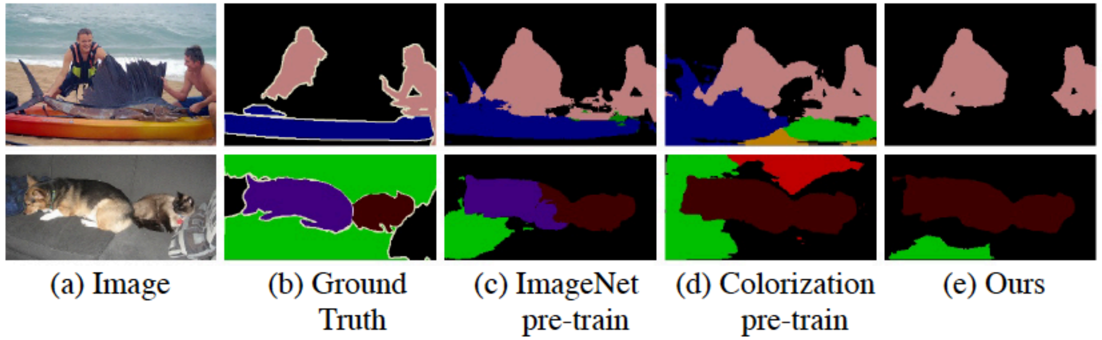


Visualization results





Failure cases

Thank You!