

Domain-Inconsistent SSOD



(a) Classical Semi-Supervised Object Detection.

Our contributions:

- We target the challenging domain-inconsistent SSOD setting for practical autonomous driving, where the labeled and unlabeled data come from different domains. Meanwhile, both the data distribution shifts and class distribution shifts are considered.

- We propose DucTeacher with two curriculum strategies, DEC and DMC, to provide accurate and unbiased pseudo-labels and improve the performance for semi-supervised object detection.

- In DucTeacher, we develop a novel class distribution estimation method to resist the class distribution shift on the unlabeled data, and a difficulty metric to estimate the domain similarity of unlabeled data from different domains. **Characteristics of Domain-Inconsistent SSOD**



(a) Correlation of domain similarity and precision.

Two challenges:

- The data distribution shifts would let the model trained on the labeled domain predict inaccurate pseudo-labels for the unlabeled domains with
- large distribution gaps. - The class distribution shifts among domains make it difficult to obtain unbiased pseudo-labels for the unlabeled domains.

(b) Domain-Inconsistent Semi-Supervised Object Detection.

(b) Data distribution shifts and class distribution shifts between domains

Dual-Curriculum Teacher (DucTeacher) distribution shifts and class distribution shifts:

- DEC: Avoiding the noise labels by learning easy domain first.
- **Predicted Bboxes**

D _{u,1}		D _{u,1}	$D_{u,2}$
			 D _{u,k}
D _{<i>u</i>,2}	Pretrained Model	D _{<i>u</i>,2}	
D _{<i>u</i>,3}		D _{<i>u</i>,3}	Class Dist
			N ^u
			N_c^l
D <i>k</i>		D_{nk}	,

Method	mAP	AP_{50}	AP_{75}	Car	Truck	Pedestrian	Cyclist	Tram	Tricycle
Supervised-only	37.9	61.6	40.4	58.3	43.2	31.0	43.2	41.3	10.5
STAC [36]	42.8 (+ 4.9)	64.8	46.0	63.4	47.5	35.7	46.4	44.4	19.6
UMT [9]	44.7 (+ 6.8)	67.5	48.2	65.1	49.9	34.6	48.1	50.2	14.3
MT-MTDA [31]	45.2 (+ 7.3)	70.4	49.4	68.6	51.8	32.4	47.5	49.4	12.5
Unbiased Teacher [29]	46.2 (+ 8.3)	70.1	50.2	67.9	53.9	33.8	50.2	55.2	16.4
MUM [24]	45.9 (+ 8.0)	71.2	49.8	66.3	53.4	35.5	48.0	48.8	23.1
DucTeacher w/o DMC	47.3 (+9.4)	72.1	51.7	66.9	53.6	36.6	50.3	55.8	20.0
DucTeacher w/o DEC	48.1 (+ 10.2)	73.3	52.2	67.0	53.9	37.1	50.5	55.7	21.3
DucTeacher (ours)	48.4 (+ 10.5)	73.5	52.4	68.7	54.3	37.9	50.9	56.6	19.0

State-of-the-art performance

Model	Overall mAP	City street (Car)		Highway (Car)		Country road (Car)			
Widdei		Clear	Overcast	Rainy	Clear	Overcast	Rainy	Clear	Overcast
Daytime									
Supervised	43.1	70.0	64.9	56.6	68.3	65.9	65.9	69.4	63.5
STAC [36]	45.3 ^{+2.2}	74.2	69.6	58.0	71.7	70.3	70.7	75.2	69.8
UMT [9]	$45.1^{+2.0}$	73.4	67.5	56.9	68.5	68.7	68.2	70.2	64.7
MT-MTDA [31]	47.1+4.0	71.8	66.0	52.9	68.3	67.8	69.8	74.5	67.5
Unbiased Teacher [29]	47.7 ^{+4.6}	73.0	68.1	55.3	69.1	62.0	71.3	72.6	70.0
DucTeacher (ours)	49.6 ^{+6.5}	76.7	68.5	55.6	69.5	70.0	71.6	73.5	69.1
Night									
Supervised	21.1	36.3	37.7	_	37.5	37.3	79.5	38.9	72.8
STAC [36]	$28.2^{+7.1}$	45.5	46.8	-	46.2	45.6	83.7	47.2	75.4
UMT [9]	$35.9^{+14.8}$	58.4	59.7	-	58.7	60.2	81.1	60.4	72.2
MT-MTDA [31]	$37.1^{+16.0}$	60.4	61.2	-	60.7	62.2	80.6	62.4	73.6
Unbiased Teacher [29]	$39.7^{+18.6}$	65.3	66.2	-	66.2	67.2	83.6	67.5	75.2
DucTeacher (ours)	40.7 ^{+19.6}	65.3	67.0	-	66.8	67.4	84.3	67.7	76.5



- DMC: Estimating the class prior and utilize it for threshold adjusting.



DucTeacher for Domain-Inconsistent SSOD (SODA10M)

Performance improvement by different modules **DucTeacher for Different Domains**



ruth	1.2
Groudt	1.0
Label /	0.8
seudo-	0.6
<u>а</u>	0.4



- DMC estimates precise class distribution, serving as the prior for threshold adjusting.



Method	1%	2%	5%	10%
upervised-only	9.05	12.70	18.47	23.86
CSD [22]	10.51 (+ 1.46)	13.93 (+ 1.23)	18.63 (+ 0.16)	22.46 (- 1.40)
STAC [36]	13.97 (+ 4.92)	18.25 (+ 5.55)	24.38 (+ 5.91)	28.64 (+ 4.78)
Int-Teaching [53]	18.05 (+ 9.00)	22.45 (+ 9.75)	26.75 (+ 8.28)	30.40 (+ 6.54)
ased Teacher [29]	19.60 (+ 10.55)	23.64 (+ 10.94)	27.85 (+ 9.38)	30.90 (+ 7.04)
cTeacher (ours)	20.35 (+ 11.30)	24.18 (+ 11.48)	28.23 (+ 9.76)	31.21 (+ 7.35)

- DEC avoids hard data at the early training stage, which also avoids miss detection.