



heuritech



SCIENCES
SORBONNE
UNIVERSITÉ

PLOP: LEARNING CONTINUOUSLY WITHOUT FORGETTING FOR CONTINUAL SEMANTIC SEGMENTATION

CVPR 2021

Arthur Douillard, *Sorbonne Université & Heuritech*

Yifu Chen, *Sorbonne Université*

Arnaud Dapogny, *Datakalab*

Matthieu Cord, *Sorbonne Université & Valeo.ai*



Machine Learning &
Deep Learning for
Information Access

Continual Learning
+
Semantic Segmentation

Continual Learning

Learning car → dog → person



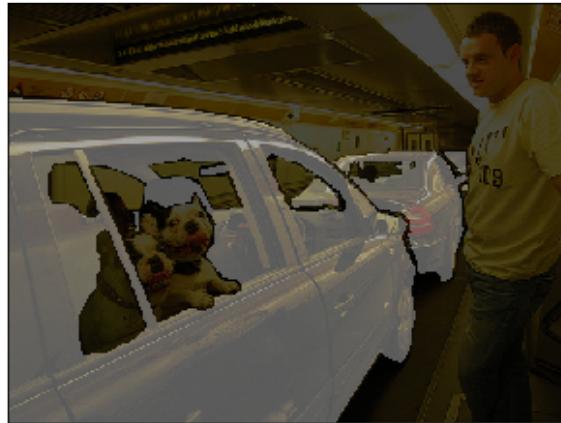
Continual Learning

Many methods in **image classification**: EWC, LwF, iCaRL...

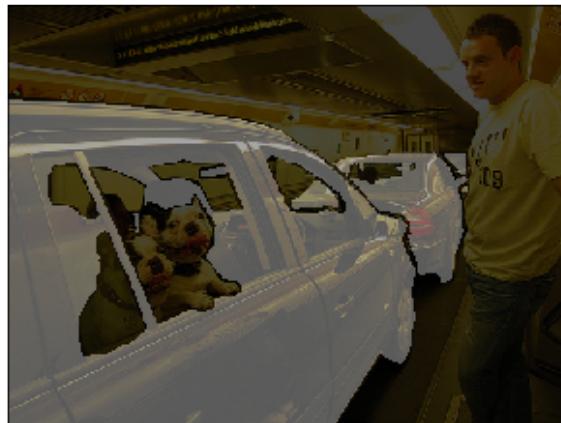
Fewly explored in **semantic segmentation**: MiB, ILT

Background shift

Task Ground-truth



Predicted Mask

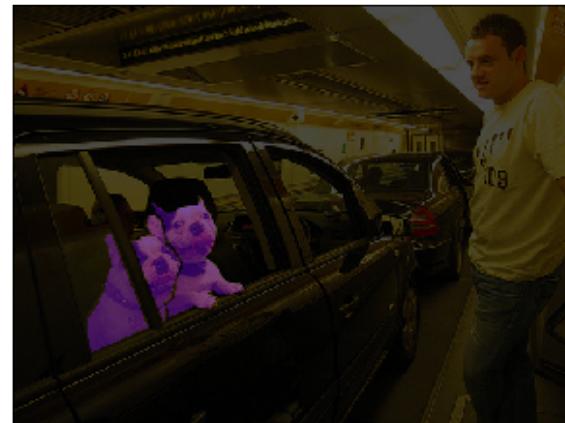
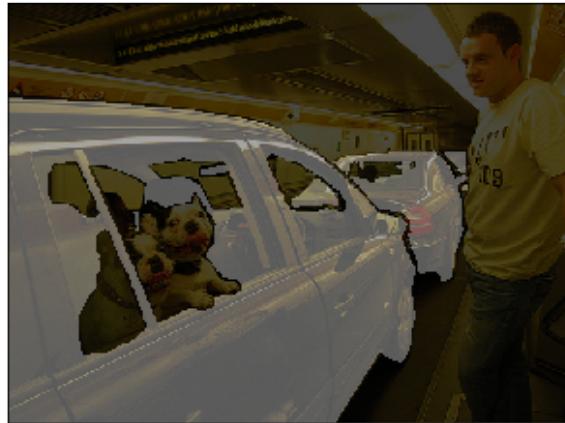


car

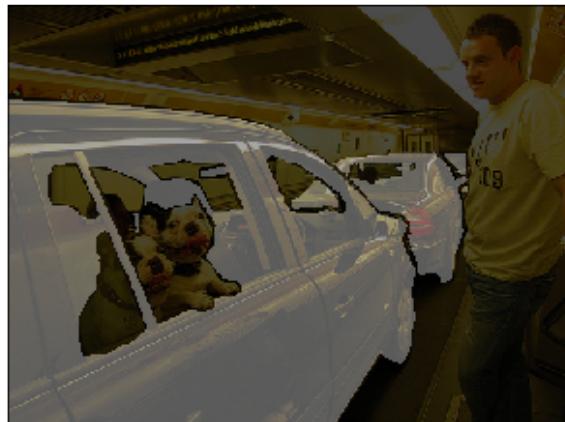
Task 1

Background shift

Task Ground-truth



Predicted Mask

**car**

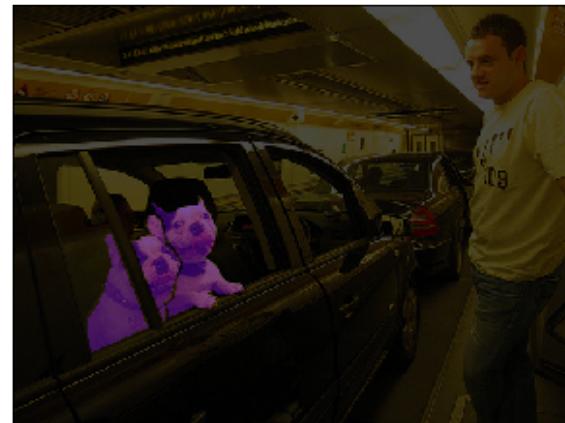
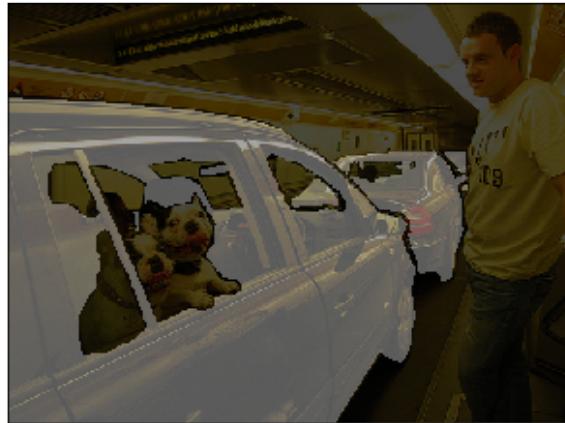
Task 1

dog

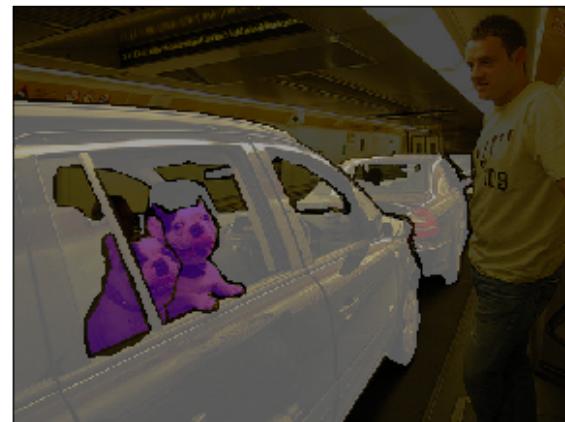
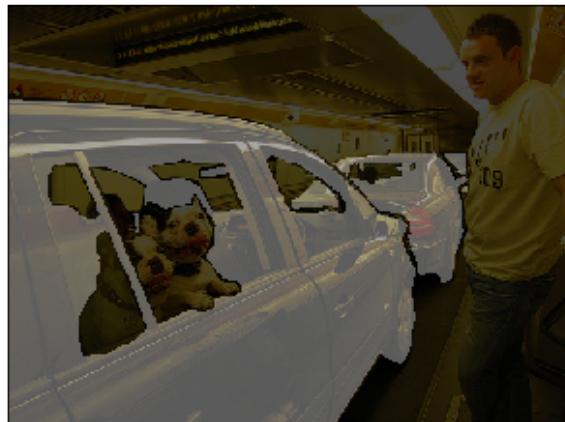
Task 2

Background shift

Task Ground-truth



Predicted Mask

**car**

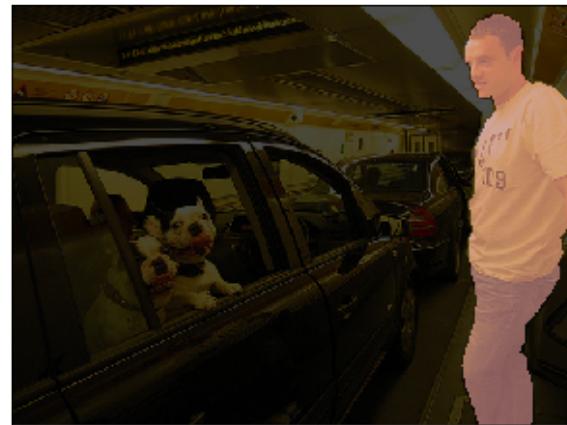
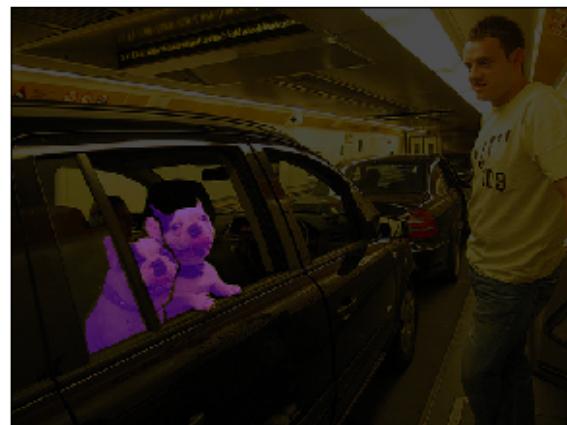
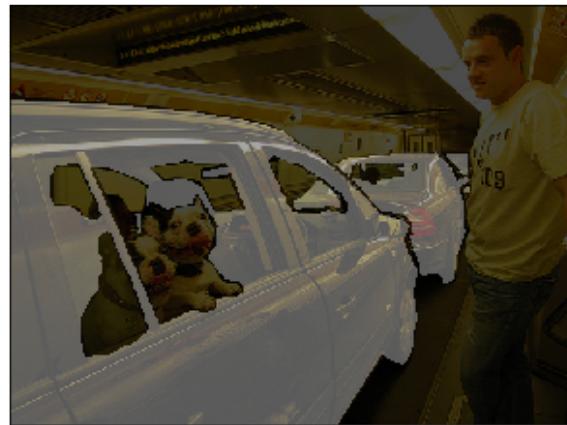
Task 1

dog

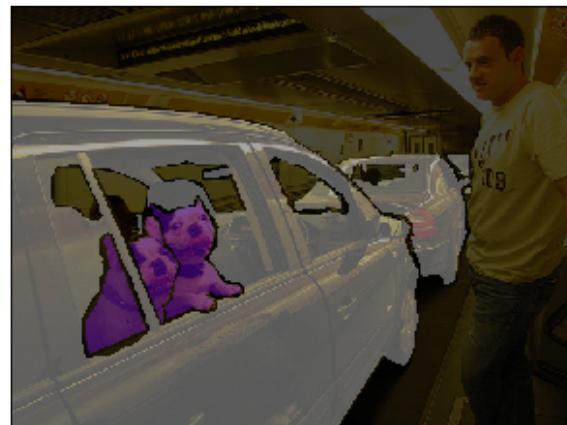
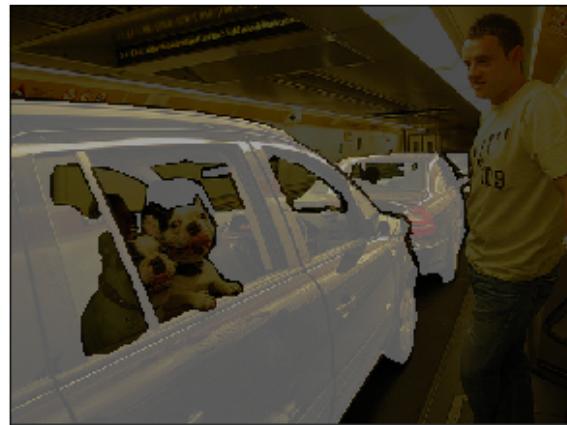
Task 2

Background shift

Task Ground-truth



Predicted Mask

**car**

Task 1

**dog**

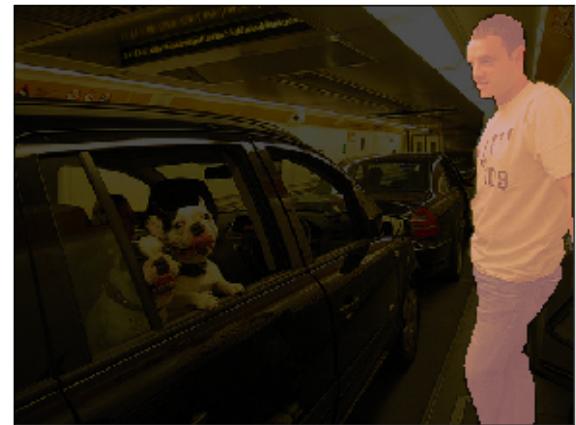
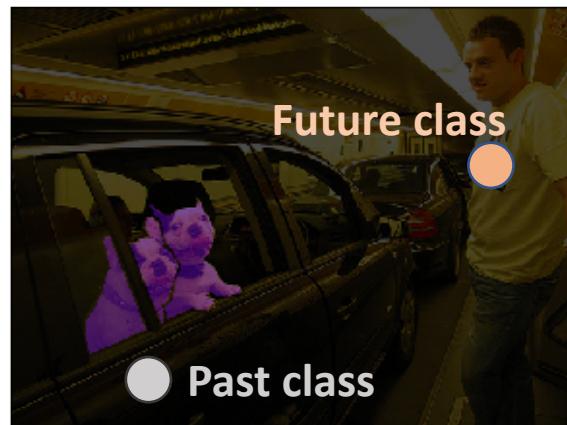
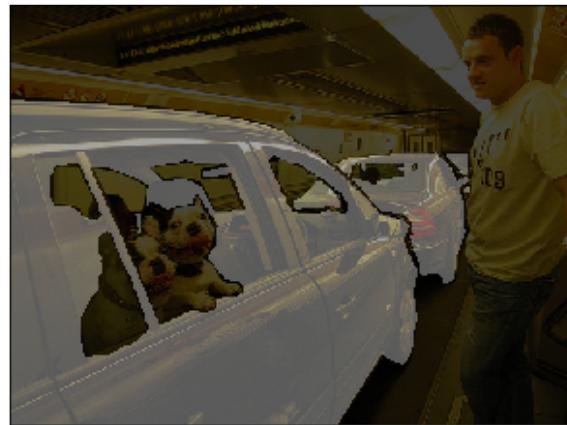
Task 2

**person**

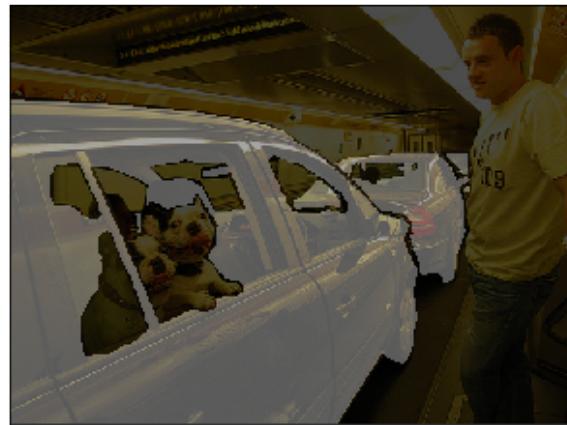
Task 3

Background shift

Task Ground-truth



Predicted Mask

**car**

Task 1

**dog**

Task 2

**person**

Task 3

Two challenges

Catastrophic Forgetting:

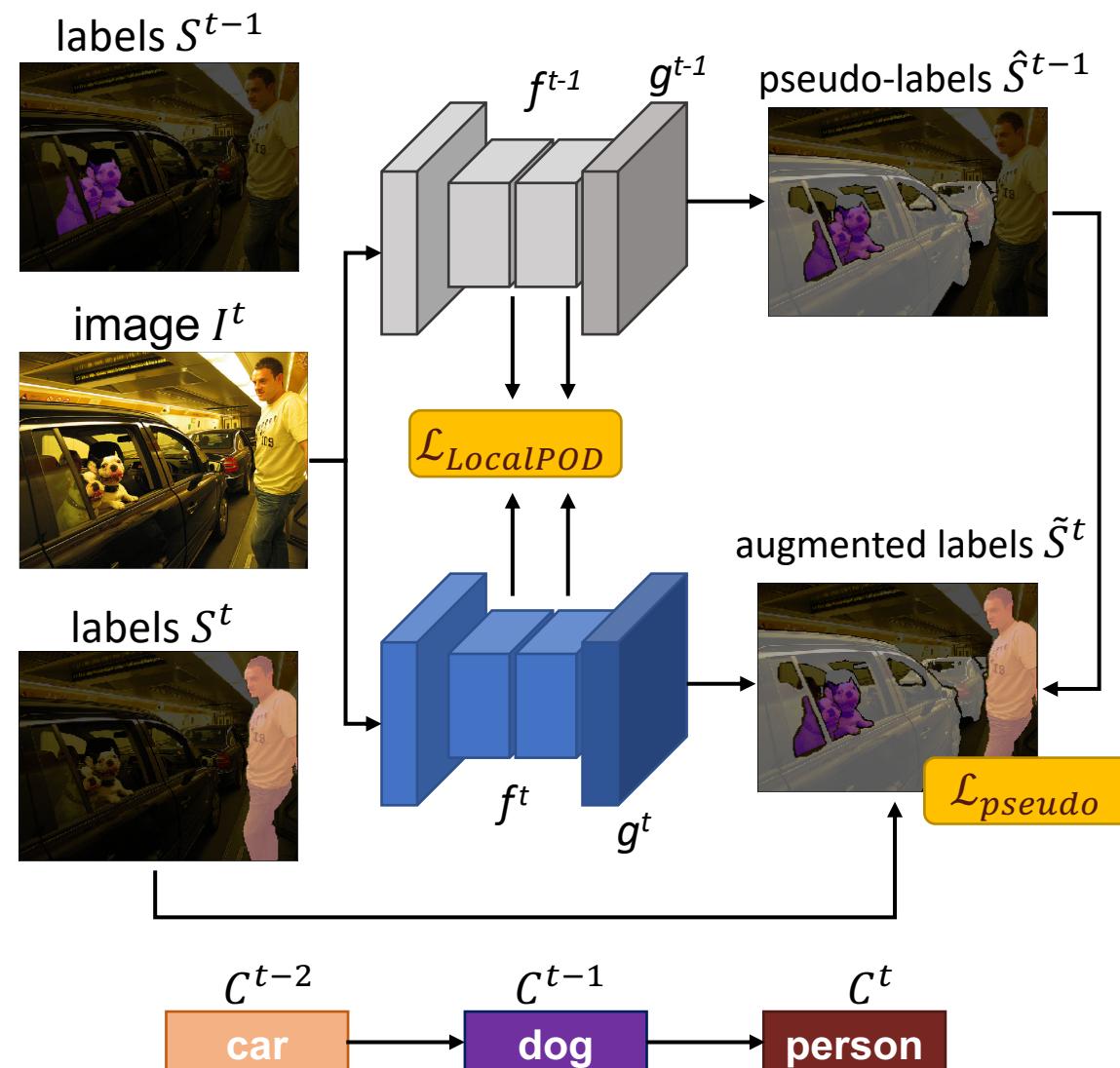
- Not forgetting previously learned classes

Background Shift:

- Incorporate updated ground-truth

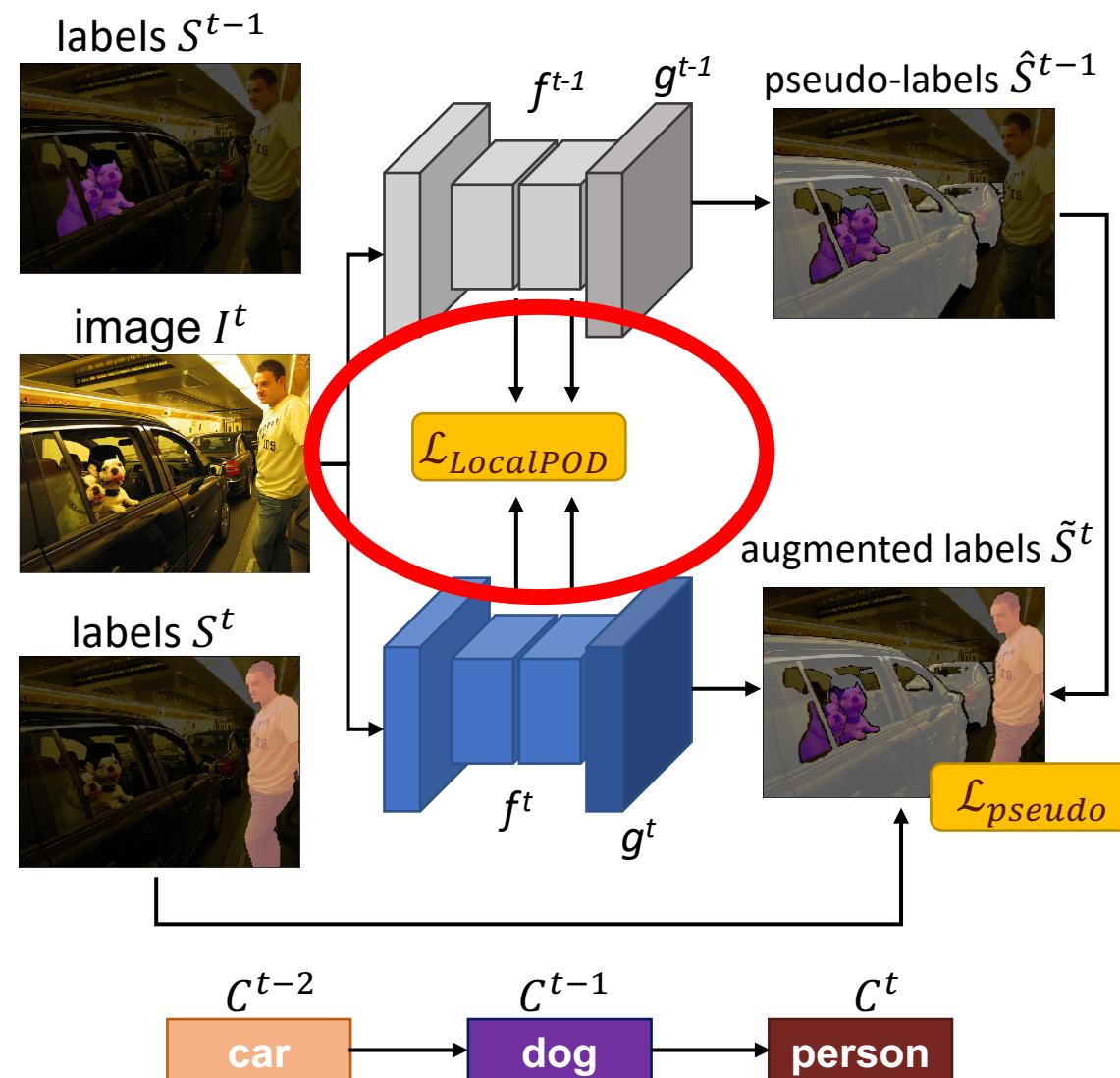
PLOP Strategy

PLOP Strategy



(a) PLOP strategy with pseudo-labeling and local POD

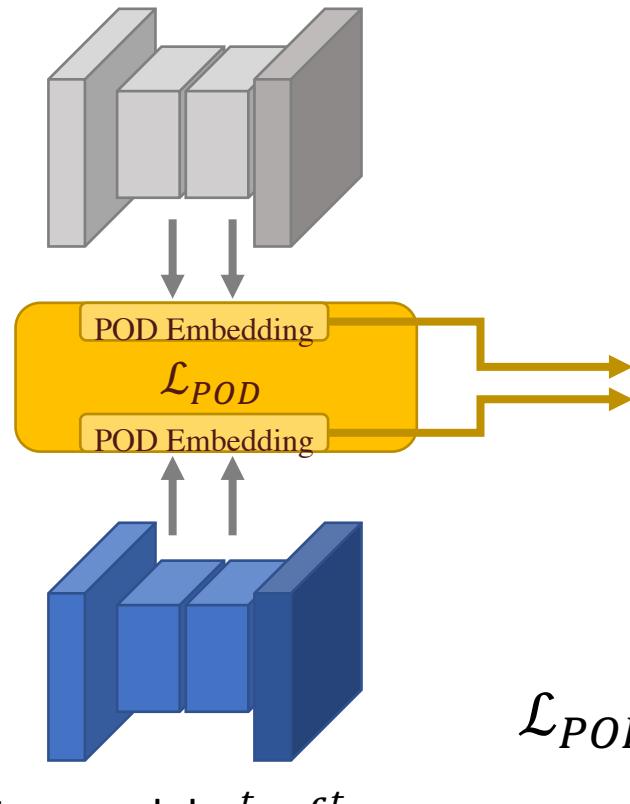
PLOP Strategy



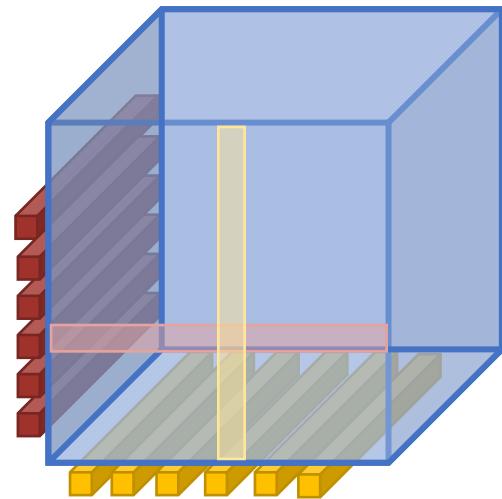
(a) PLOP strategy with pseudo-labeling and local POD

Local POD

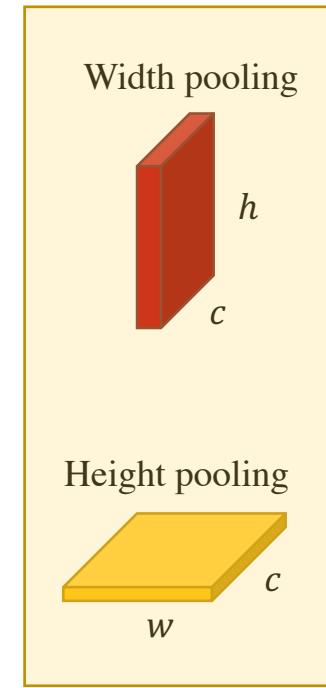
Old model $g^{t-1} \circ f^{t-1}$



Feature maps

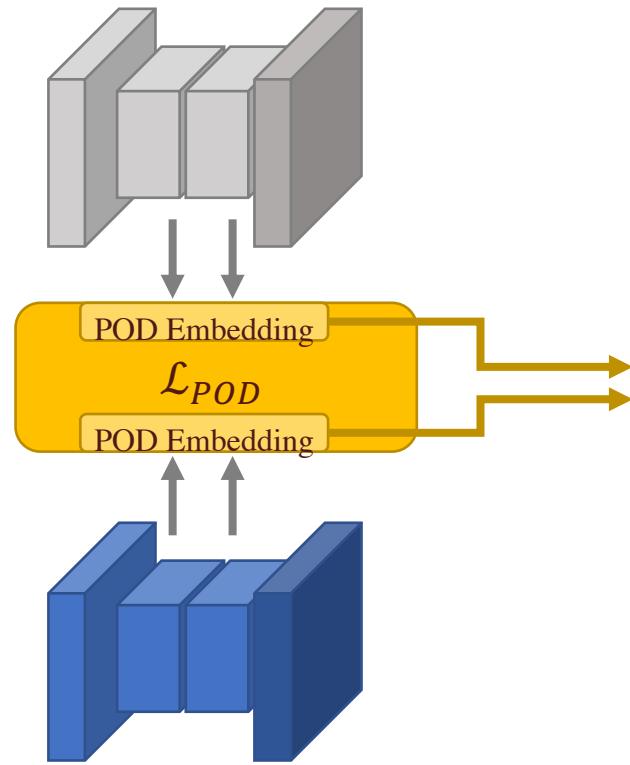


$$\mathcal{L}_{POD} = \|\Phi^t - \Phi^{t-1}\|^2$$

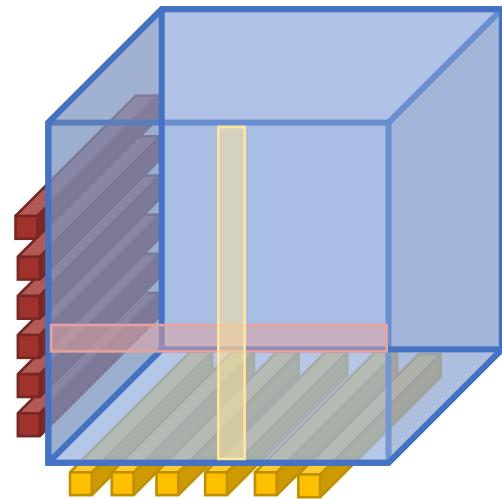


POD
Embedding
 Φ^t

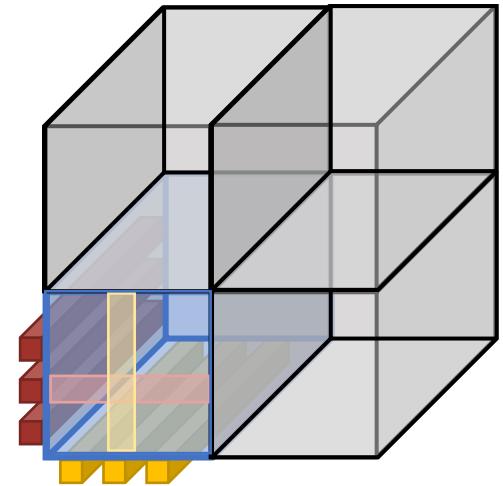
Local POD

Old model $g^{t-1} \circ f^{t-1}$ 

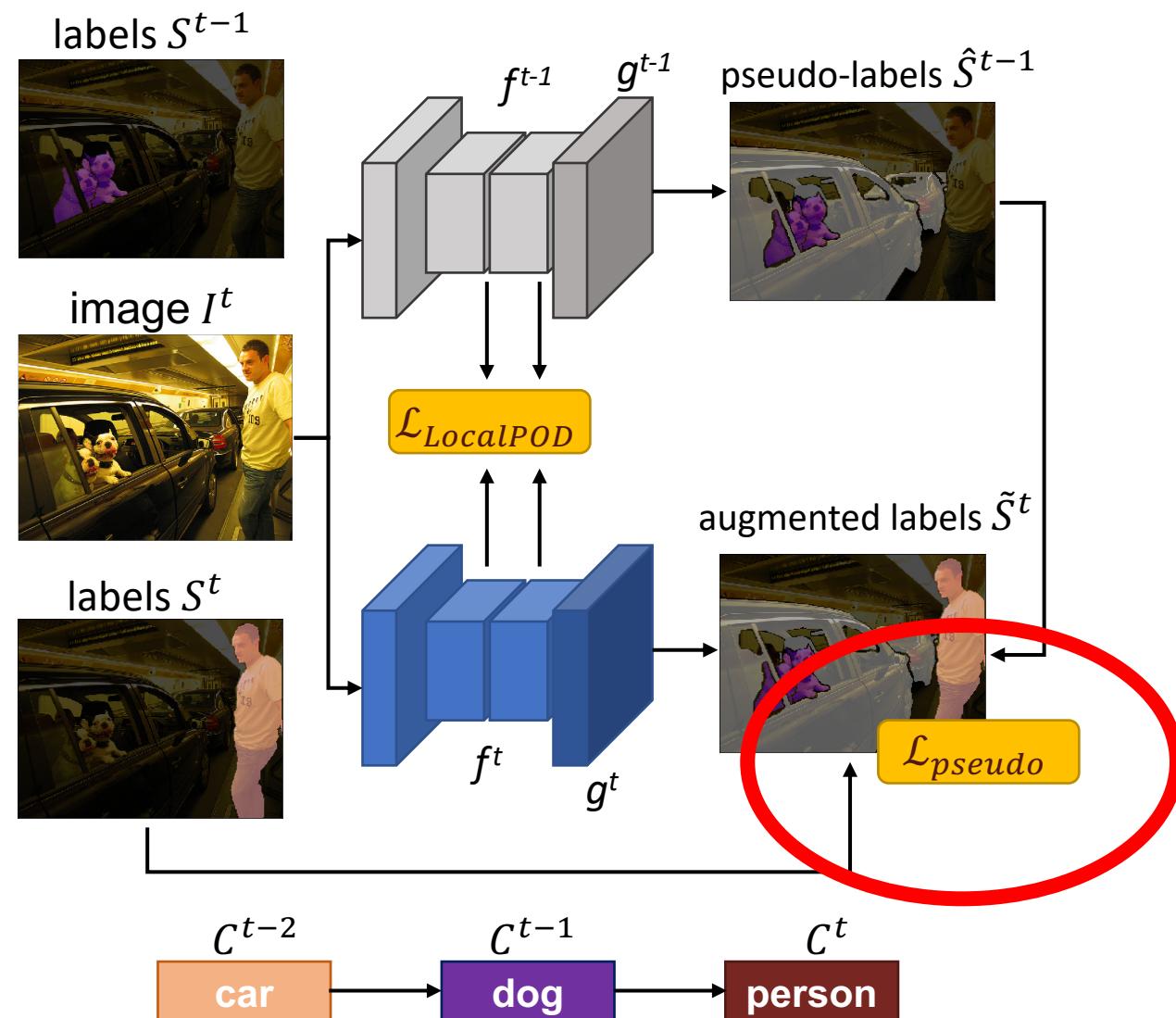
Global Scale



Local Scale

New model $g^t \circ f^t$

PLOP Strategy



(a) PLOP strategy with pseudo-labeling and local POD

Pseudo-Labeling

Step 1

GT



Current Predictions



Pseudo-Labeling

GT

Step 1



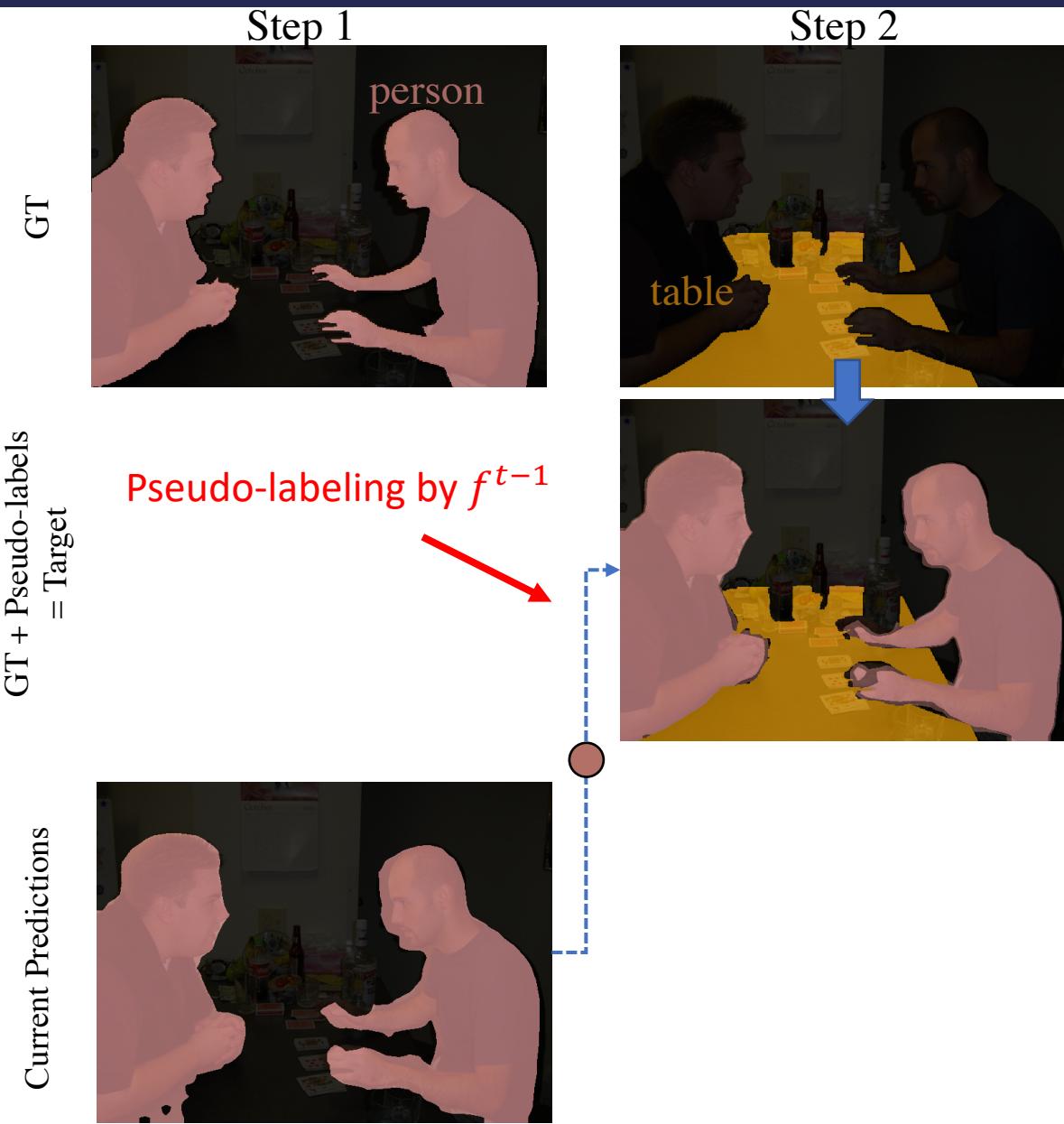
Step 2



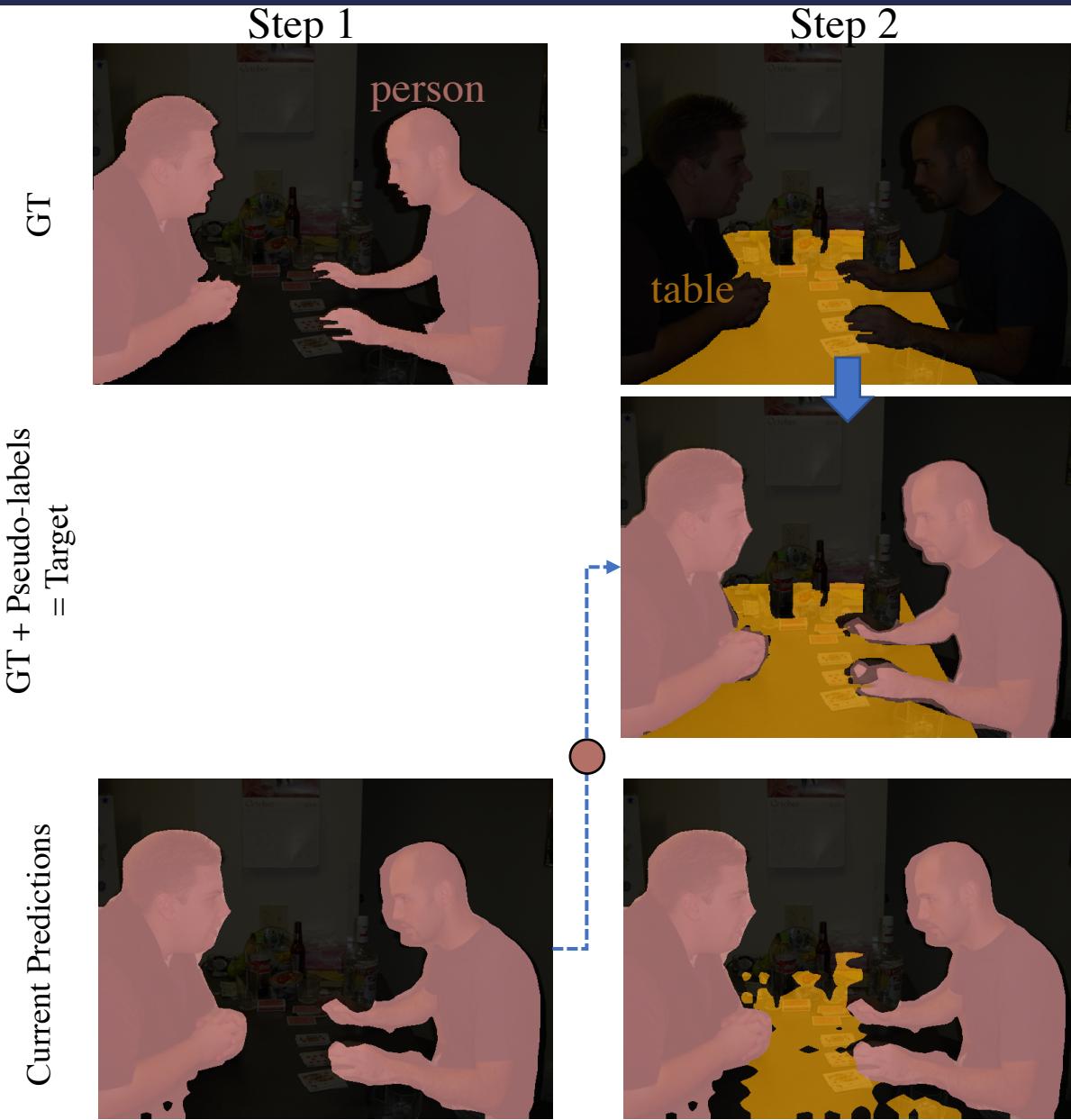
Current Predictions



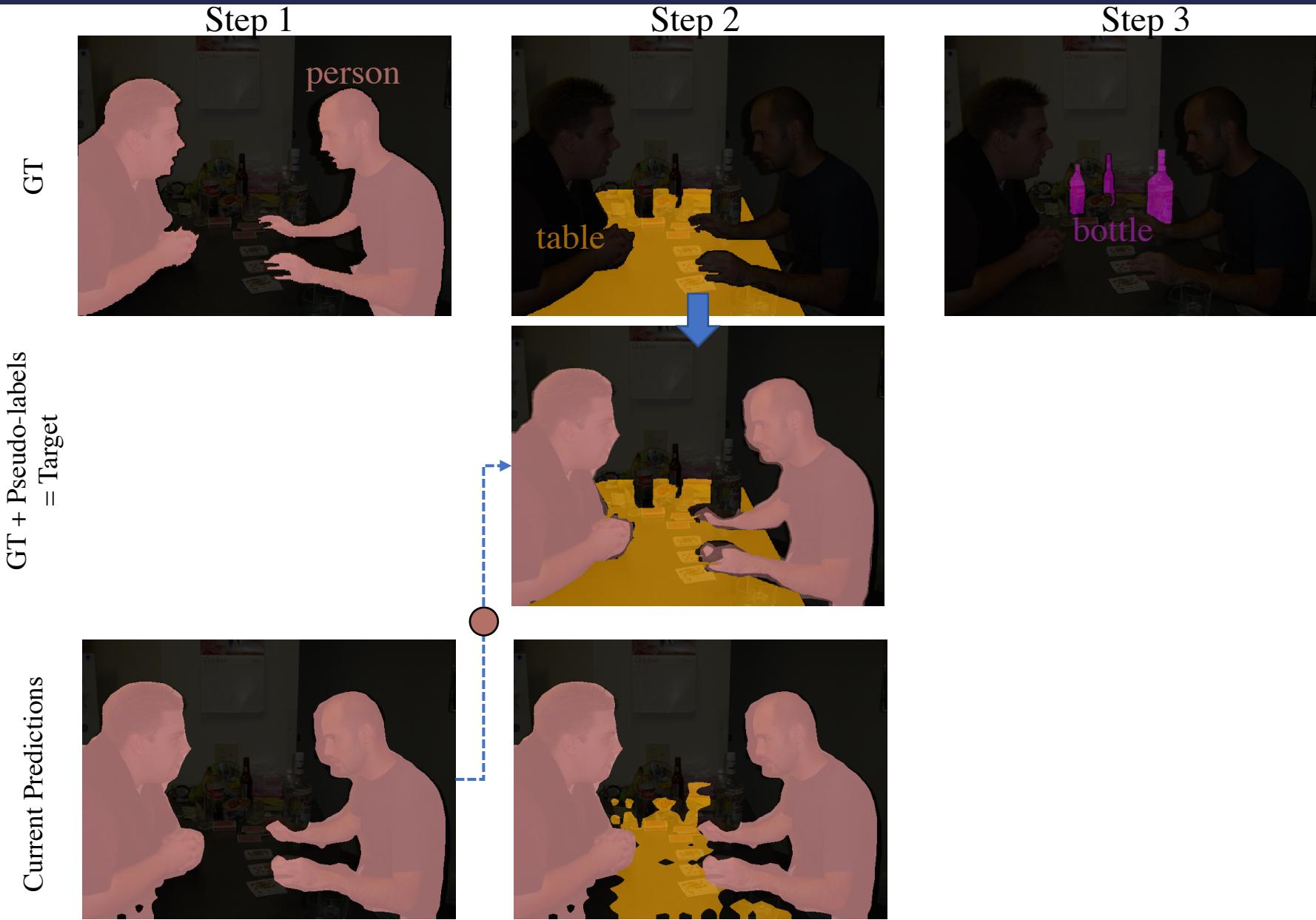
Pseudo-Labeling



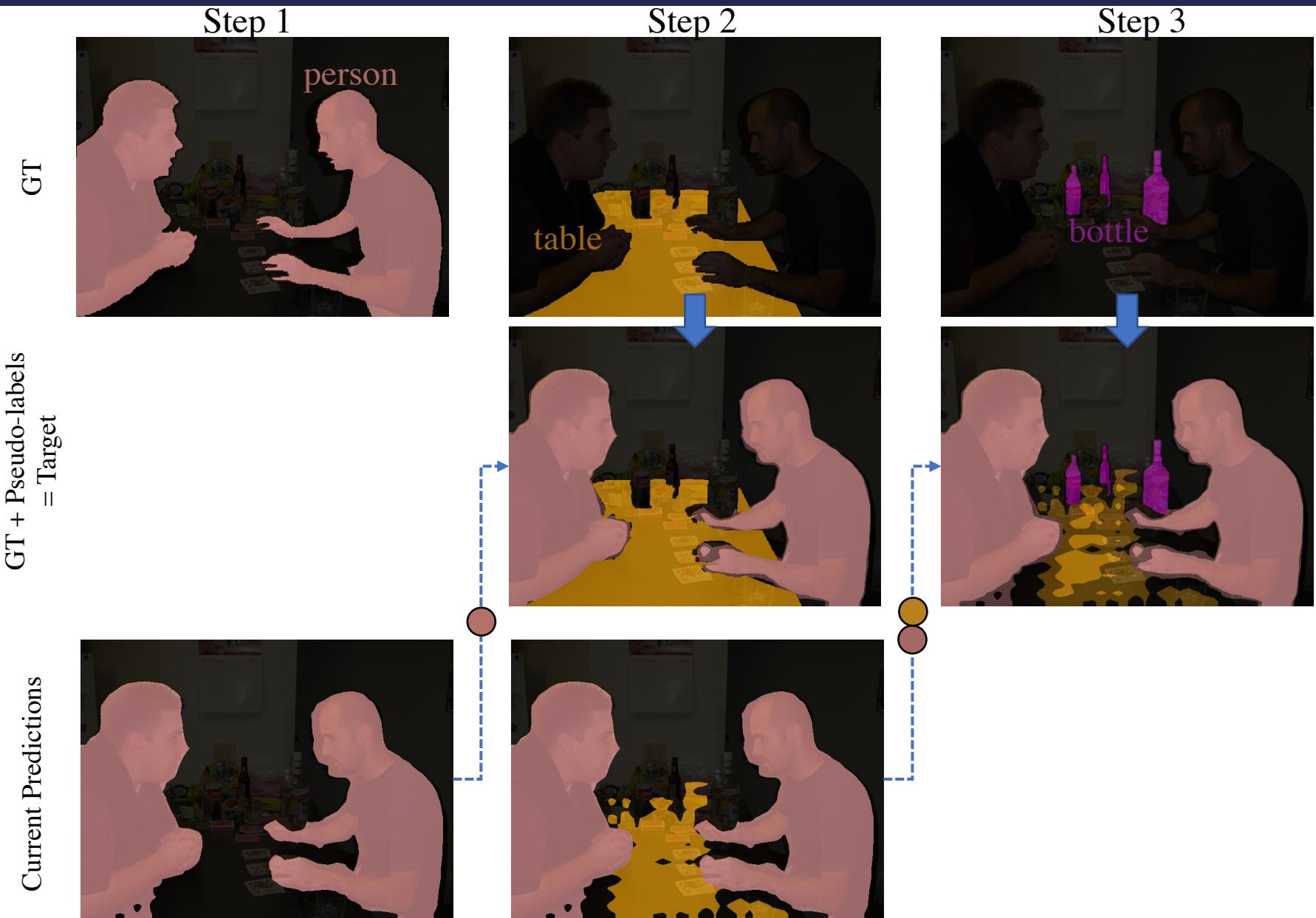
Pseudo-Labeling



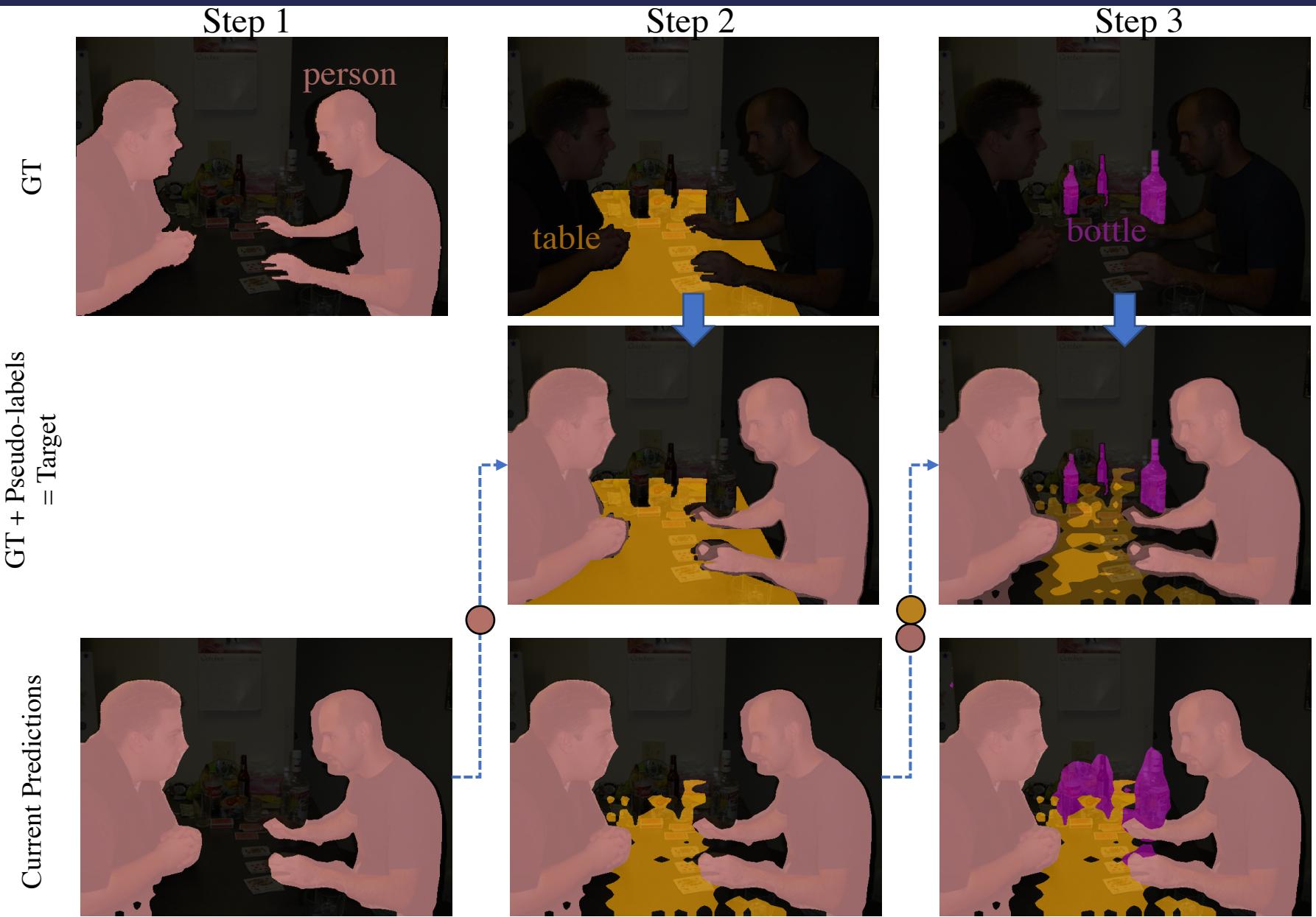
Pseudo-Labeling



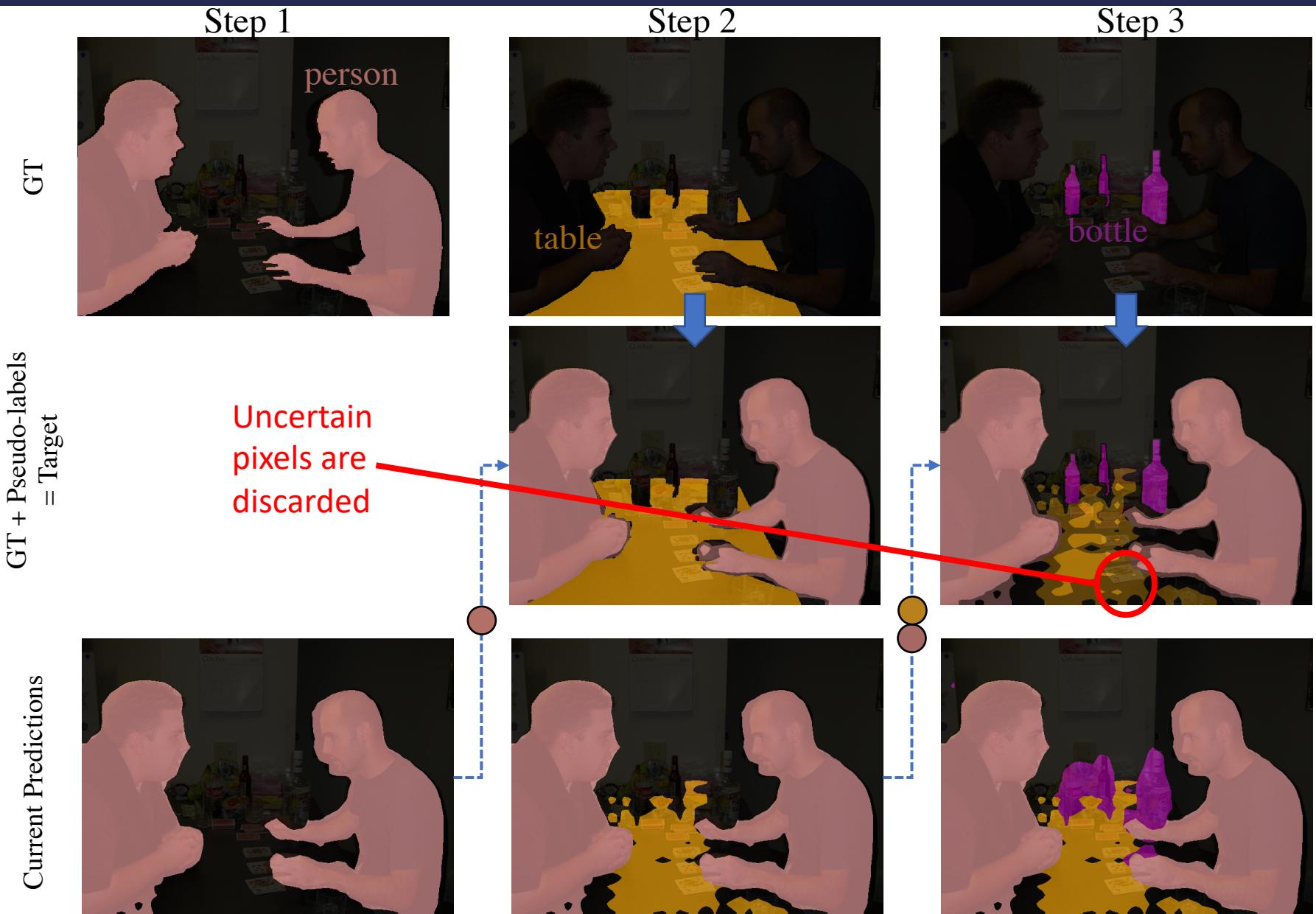
Pseudo-Labeling



Pseudo-Labeling

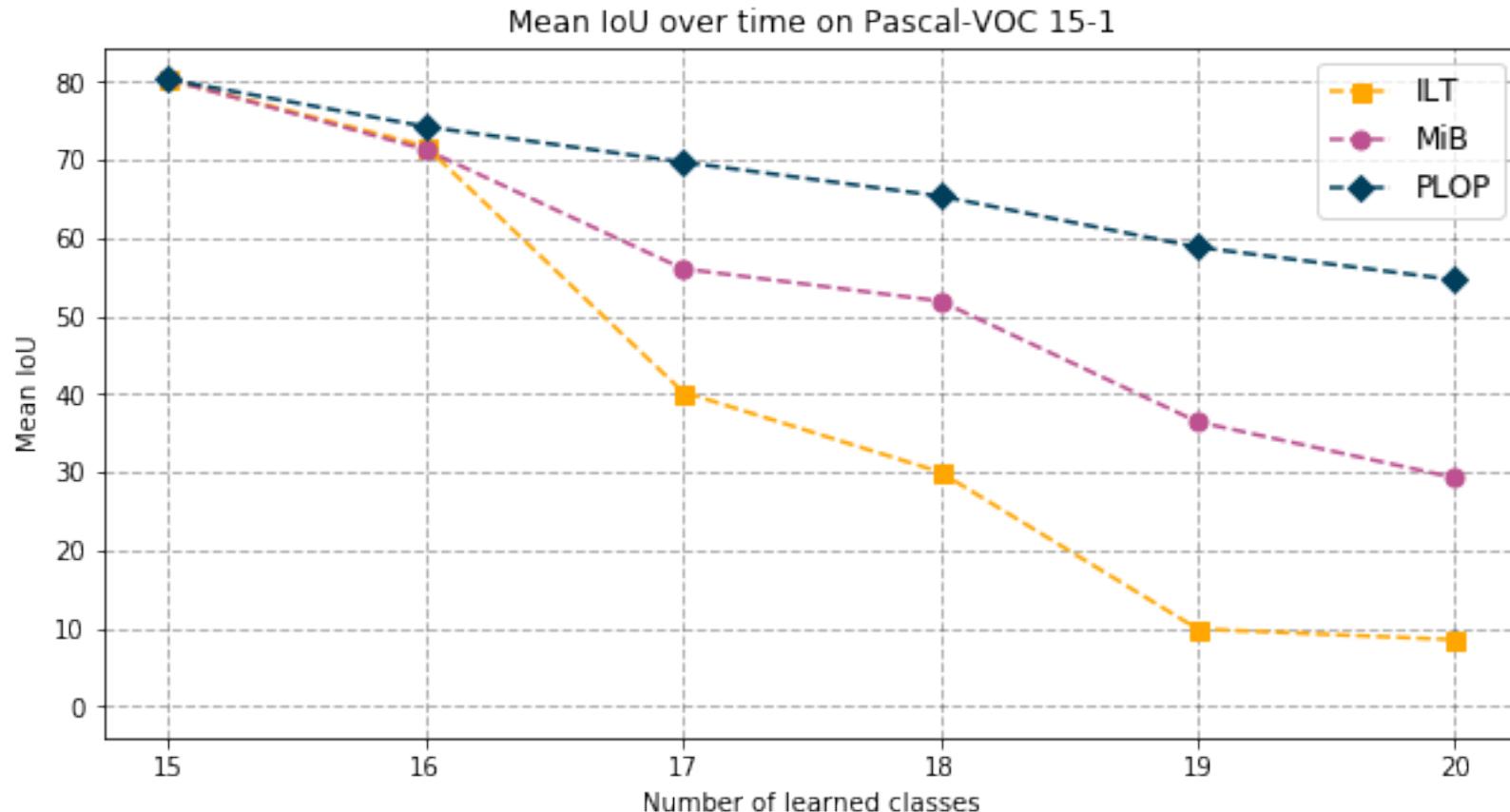


Pseudo-Labeling



Experiments

Pascal-VOC (20 classes) experiments



Experiments

Pascal-VOC (20 classes) experiments

Method	15-1 (6 tasks)				10-1 (11 tasks)			
	0-15	16-20	<i>all</i>	avg	0-10	11-20	<i>all</i>	avg
ILT	8.75	7.99	8.56	40.16	7.15	3.67	5.50	25.71
MiB	34.22	13.50	29.29	54.19	12.25	13.09	12.65	42.67
PLOP	65.12	21.11	54.64	67.21	44.03	15.51	30.45	52.32

ADE20k (150 classes) experiments

Method	100-10 (6 tasks)				100-5 (11 tasks)			
	0-100	101-150	<i>all</i>	avg	0-100	101-150	<i>all</i>	avg
ILT	0.11	3.06	1.09	12.56	0.08	1.31	0.49	7.83
MiB	38.21	11.12	29.24	35.12	36.01	5.66	25.96	32.69
PLOP	40.48	13.61	31.59	36.64	39.11	7.81	28.75	35.25

Visuals

Step 1

1-15



MiB



PLOP



MiB



PLOP

First, learn 15 classes

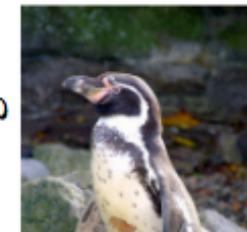
Image



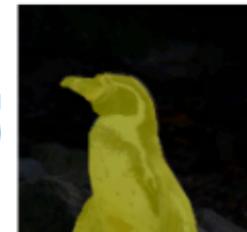
GT



Image



GT



Visuals

Step 1

1-15

Step 2

16 (plant)

MiB



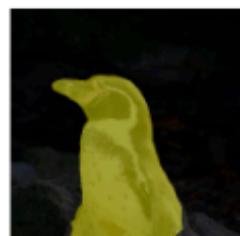
PLOP



MiB



PLOP



Image



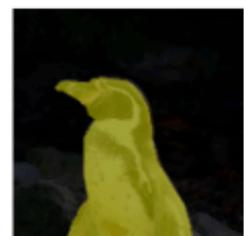
GT



Image



GT



Visuals

Step 1

1-15



Step 2

16 (plant)



Step 3

17 (sheep)



MiB



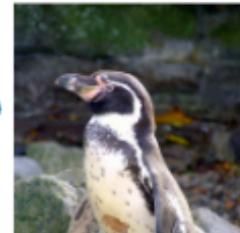
Image



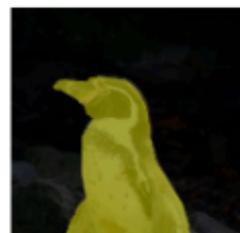
GT



Image



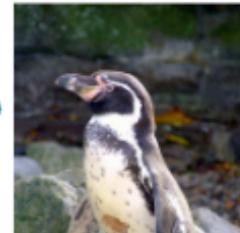
GT



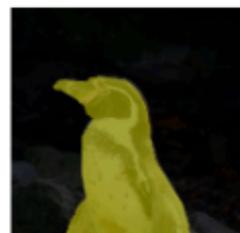
PLOP



Image



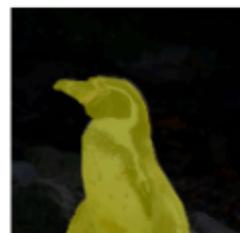
GT



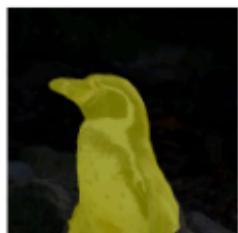
MiB



GT



PLOP



Visuals

Step 1

1-15



Step 2

16 (plant)



Step 3

17 (sheep)



Step 4

18 (sofa)



MiB



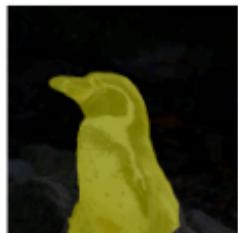
PLOP



MiB



PLOP



Image



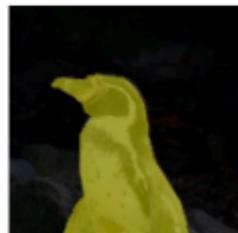
GT



Image



GT



Visuals

Step 1

1-15



Step 2

16 (plant)



Step 3

17 (sheep)



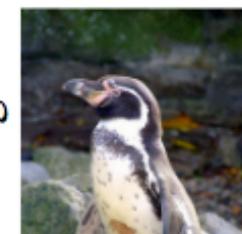
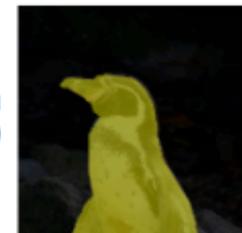
Step 4

18 (sofa)



Step 5

19 (train)

MiB
ImagePLOP
GTMiB
ImagePLOP
GT

Visuals

Step 1

1-15



Step 2

16 (plant)



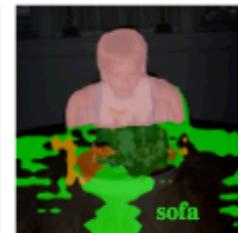
Step 3

17 (sheep)



Step 4

18 (sofa)



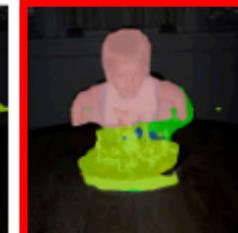
Step 5

19 (train)



Step 6

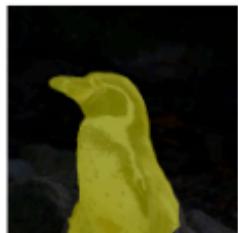
20 (TV)



Image



MiB



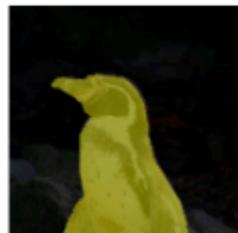
GT



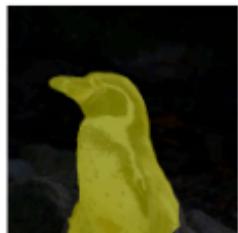
Image



GT



PLOP



Image



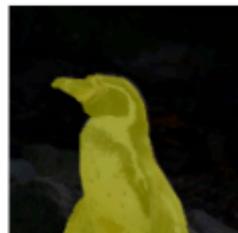
GT



Image



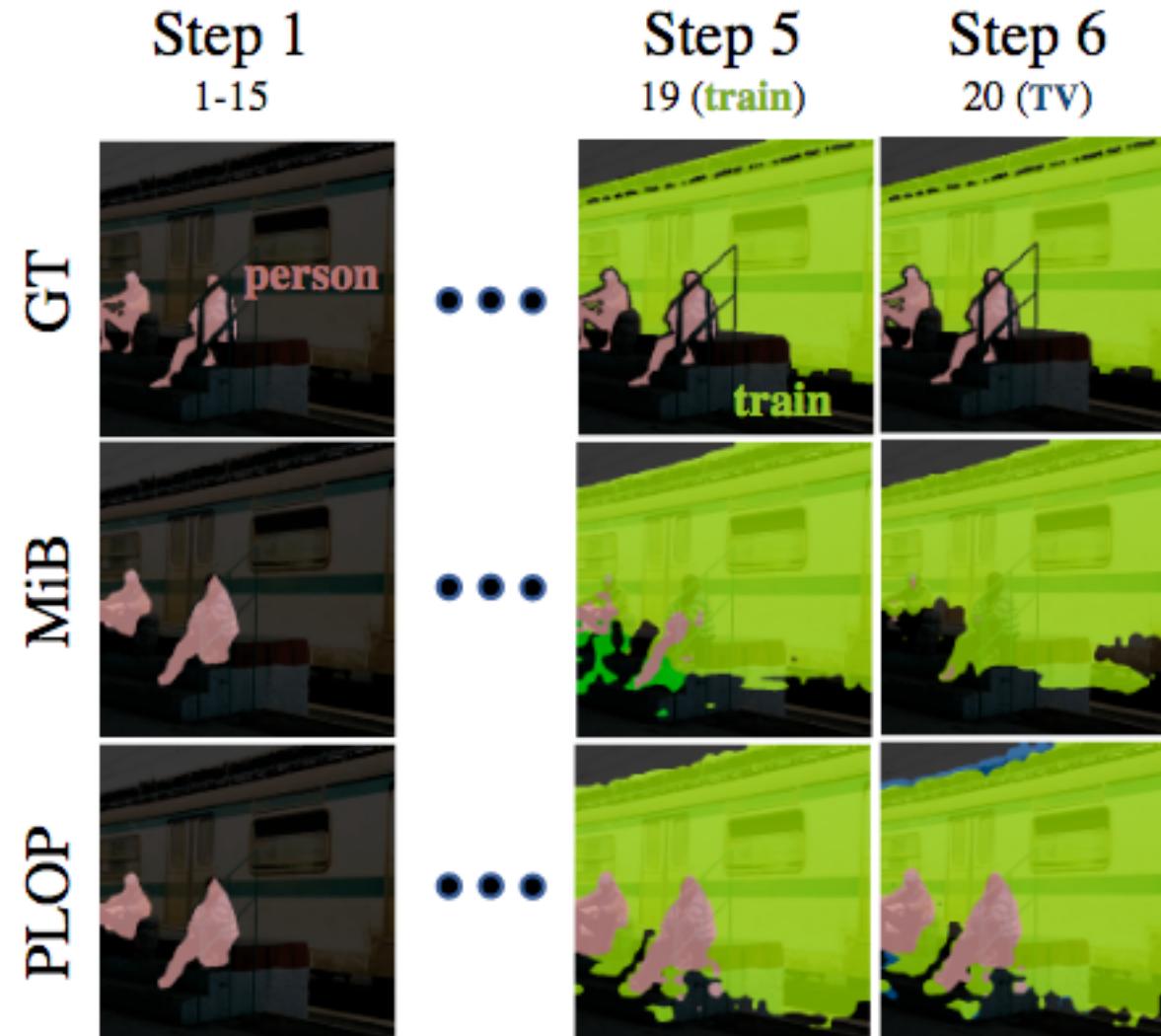
GT



PLOP

Visuals

When a class appear only latter in the image



Thank you for listening

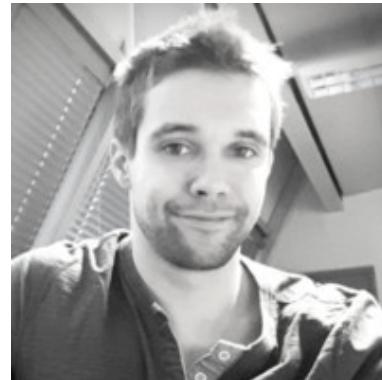
The Team



Arthur Douillard
*Sorbonne Université
Heuritech*



Yifu Chen
Sorbonne Université



Arnaud Dapogny
Datakalab



Matthieu Cord
*Sorbonne Université
Valeo.ai*