KI DELTA LEARNING
Scalable AI for Automated Driving

Final Event | March 09, 2023

Heterogeneous Continual Learning

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Topics

- Continual Learning – A Brief Overview
  - Semantic Segmentation

- Heterogeneous Continual Learning
  - Experimental Design
  - Results for Semantic Segmentation

Continual Learning - A Brief Overview

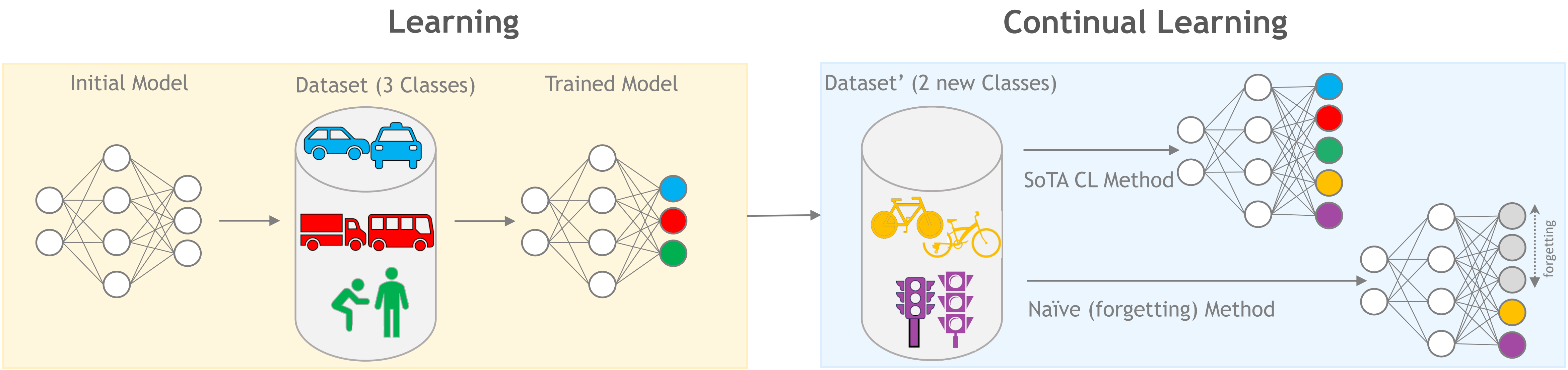
Types of Continual Learning

Types of Continual Learning

Class Incremental

Domain Incremental

Concept Illustration of Class Incremental Continual Learning



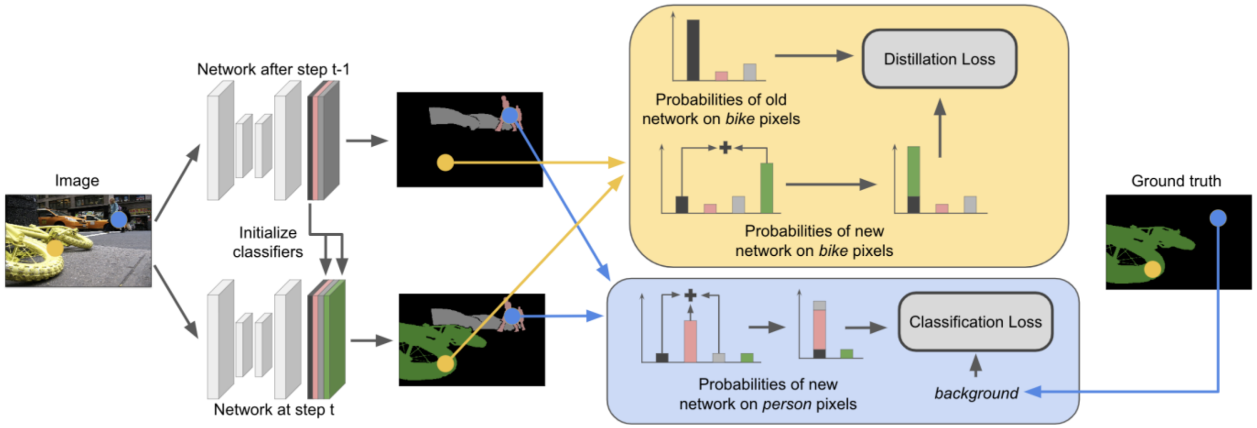
SoTA - CL Semantic Segmentation

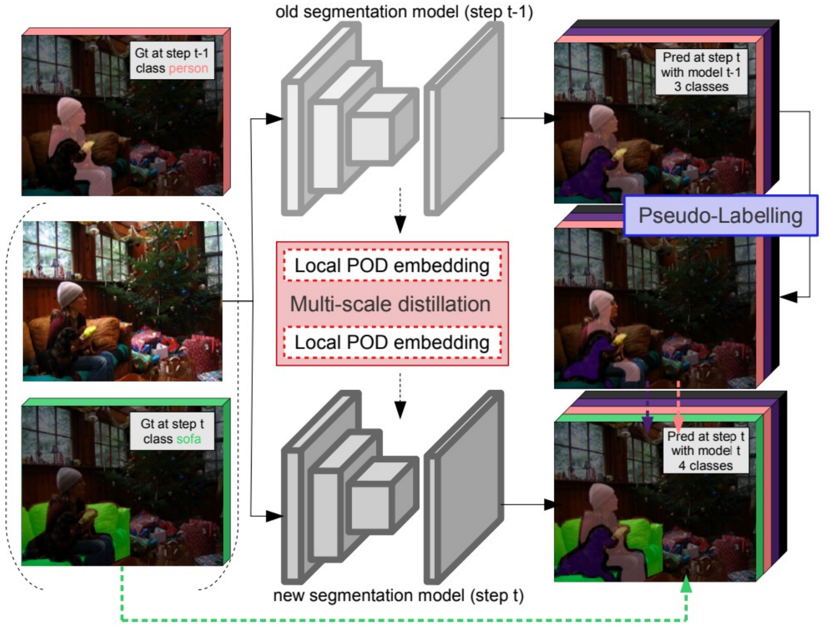
MiB[1]

- addresses the issue of background shift along with catastrophic forgetting

PLOP[2]

- addresses the issue of catastrophic forgetting using a multi-scale pooling distillation loss





[1] Cermelli et al. "Modeling the Background for Incremental Learning in Semantic Segmentation", CVPR 2020.
[2] Douillard et al. "PLOP: Learning without Forgetting for Continual Semantic Segmentation", CVPR 2021.

Dataset & Network

- Cityscapes Dataset [3]

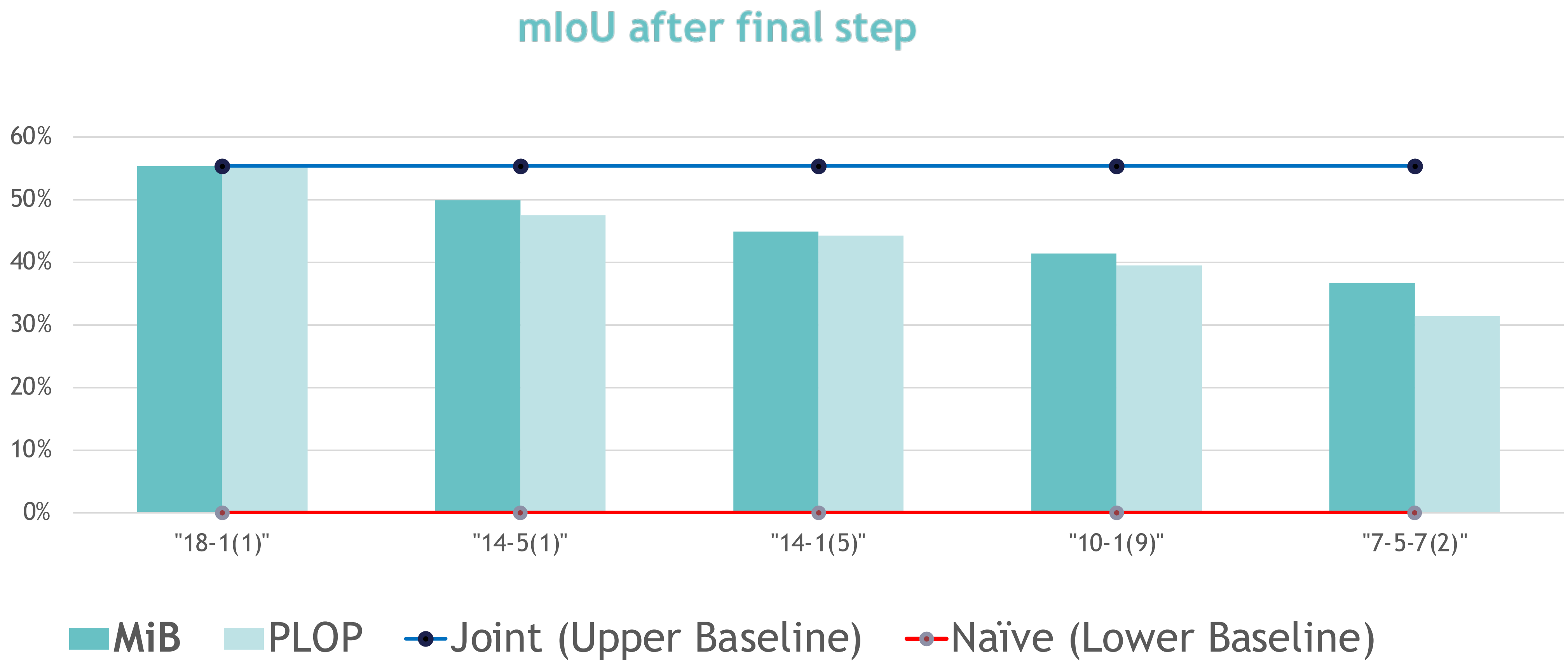
ID	Name	Category	Color
1	Road	Flat	
2	Sidewalk		
3	Building	Construction	
4	Wall		
5	Fence		
6	Pole	Object	
7	Traffic light		
8	Traffic sign		
9	Vegetation	Nature	
10	Terrain		
11	Sky	Sky	
12	Person	Human	
13	Rider		
14	Car	Vehicle	
15	Truck		
16	Bus		
17	Train		
18	Motorcycle		
19	Bicycle		

- DeepLabv3 [4] with ResNet101 [5]

[3] Cordts et al. "The Cityscapes Dataset for Semantic Urban Scene Understanding", CVPR 2016.
[4] Chen et al. "Rethinking Atrous Convolution for Semantic Image Segmentation", arXiv:1706.05587
[5] He et al. "Deep Residual Learning for Image Recognition", arXiv:1512.03385

Results: MiB vs PLOP

R&R3 Workshop (03.10.2022)



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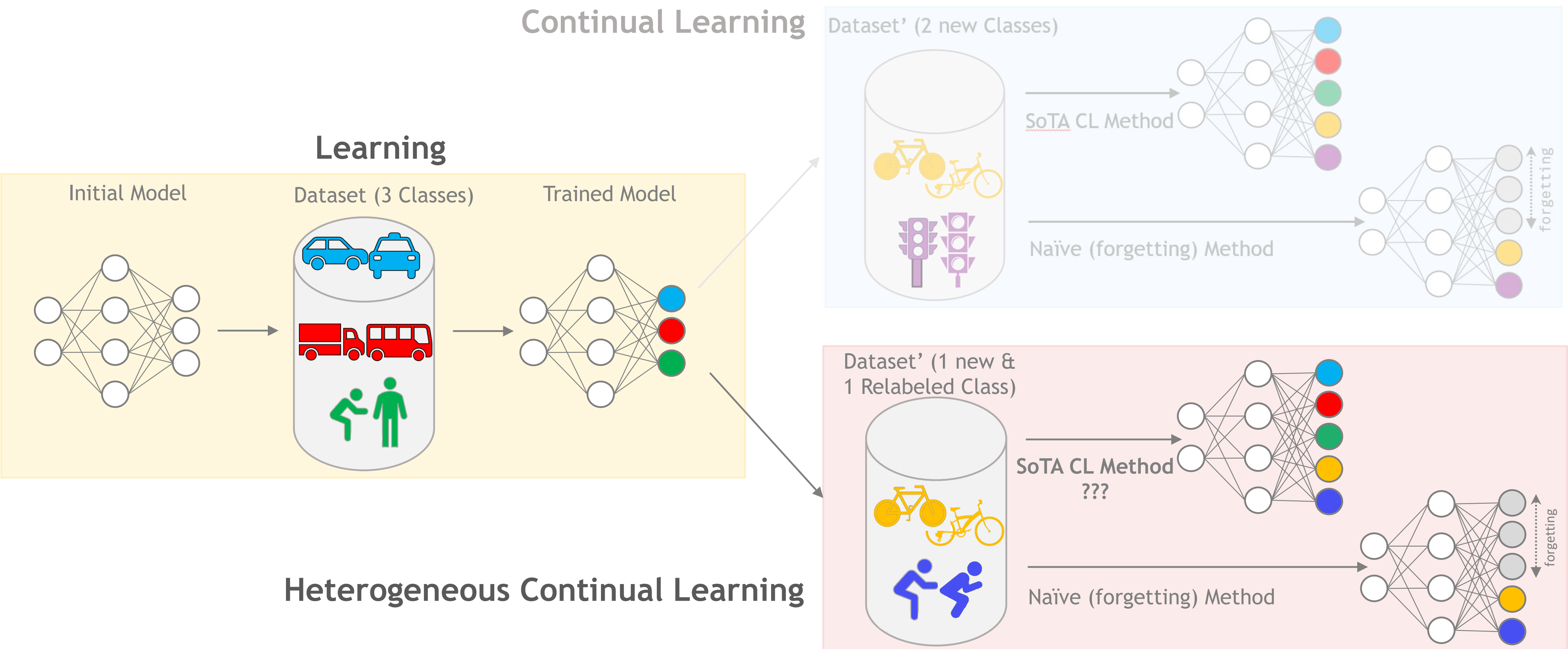
Heterogeneous Continual Learning

Concept Illustration of Class Incremental Heterogeneous Continual Learning



Semantic Segmentation with Heterogeneous Continual Learning

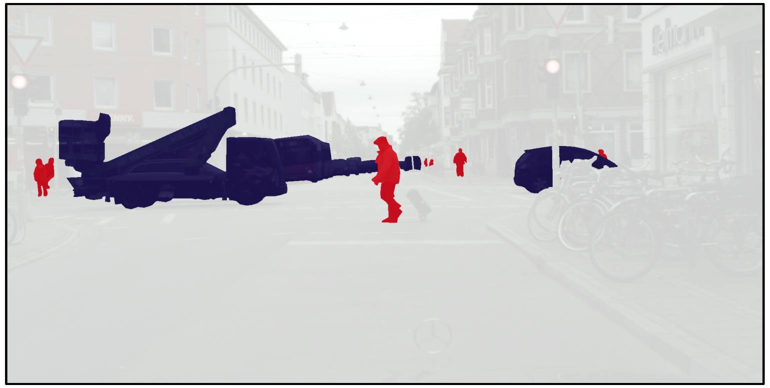
Definition:

- An incremental task add new class(es) but may also redefine previous information

Goals:

- Defining suitable experiments
- Benchmark a Class Incremental Sem-Seg model

A Sample



Initial classes [T0]: Vehicle & Human

Increment [T1]: Car & Bicycle

Joint (Classes After Final Step): Vehicle(-cars), Human, Car & Bicycle

Classes in our Experiments

- Original IDs and colors of Cityscapes [1]
- Color of superclass is the average of the sub-classes' color

ID	Name	Category	Color
12	Person	Human	
13	Rider		
14	Car	Vehicle	
15	Truck		
16	Bus		
19	Bicycle		
20	*Vehicle*	*Superclass*	
21	*Human*		

6 Selected Classes from Cityscapes + 2 Superclasses

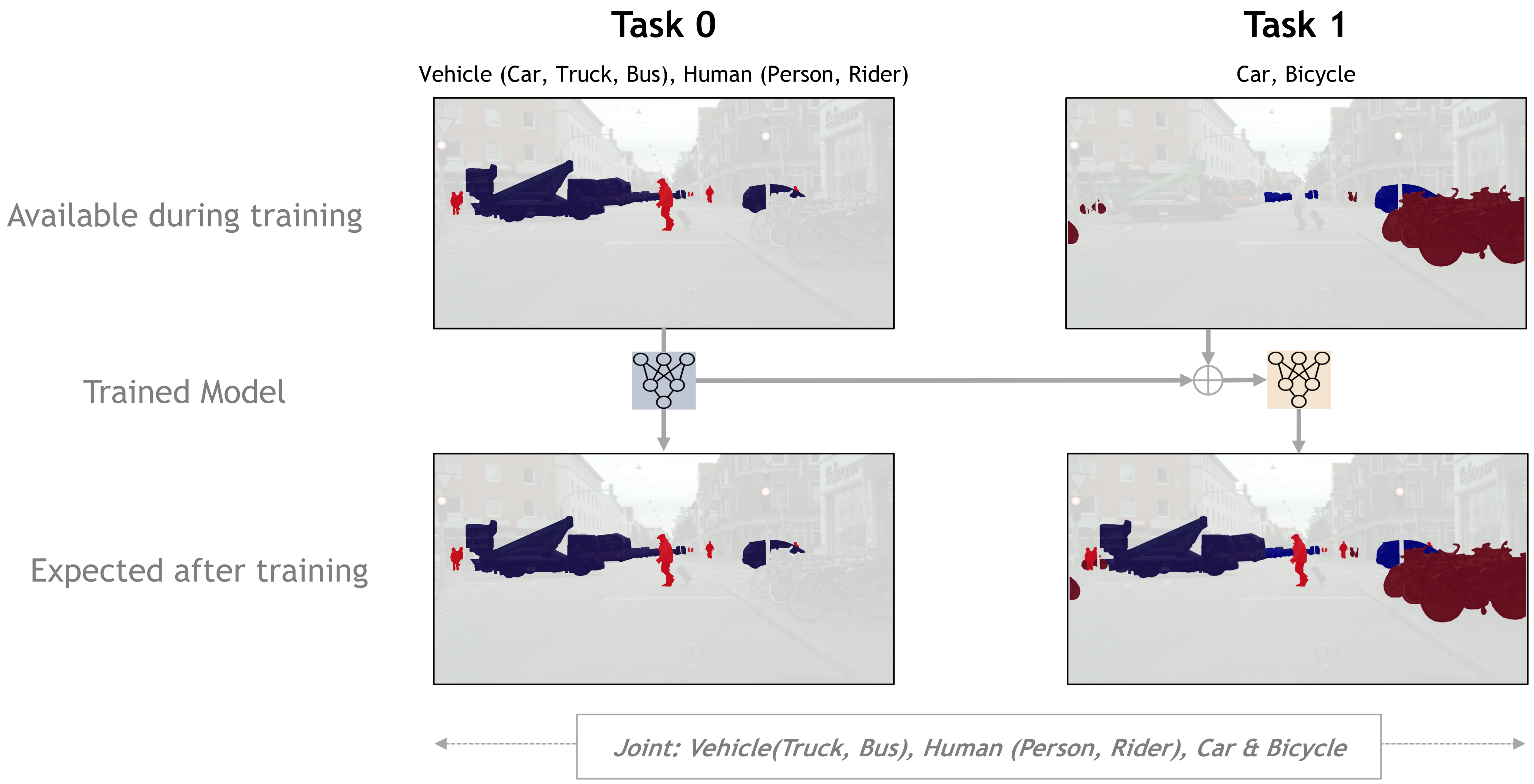
ID	Name	Category	Color
1	Road	Flat	
2	Sidewalk		
3	Building	Construction	
4	Wall		
5	Fence		
6	Pole	Object	
7	Traffic light		
8	Traffic sign		
9	Vegetation	Nature	
10	Terrain		
11	Sky	Sky	
12	Person	Human	
13	Rider		
14	Car	Vehicle	
15	Truck		
16	Bus		
17	Train		
18	Motorcycle		
19	Bicycle		

All 19 Classes of Cityscapes

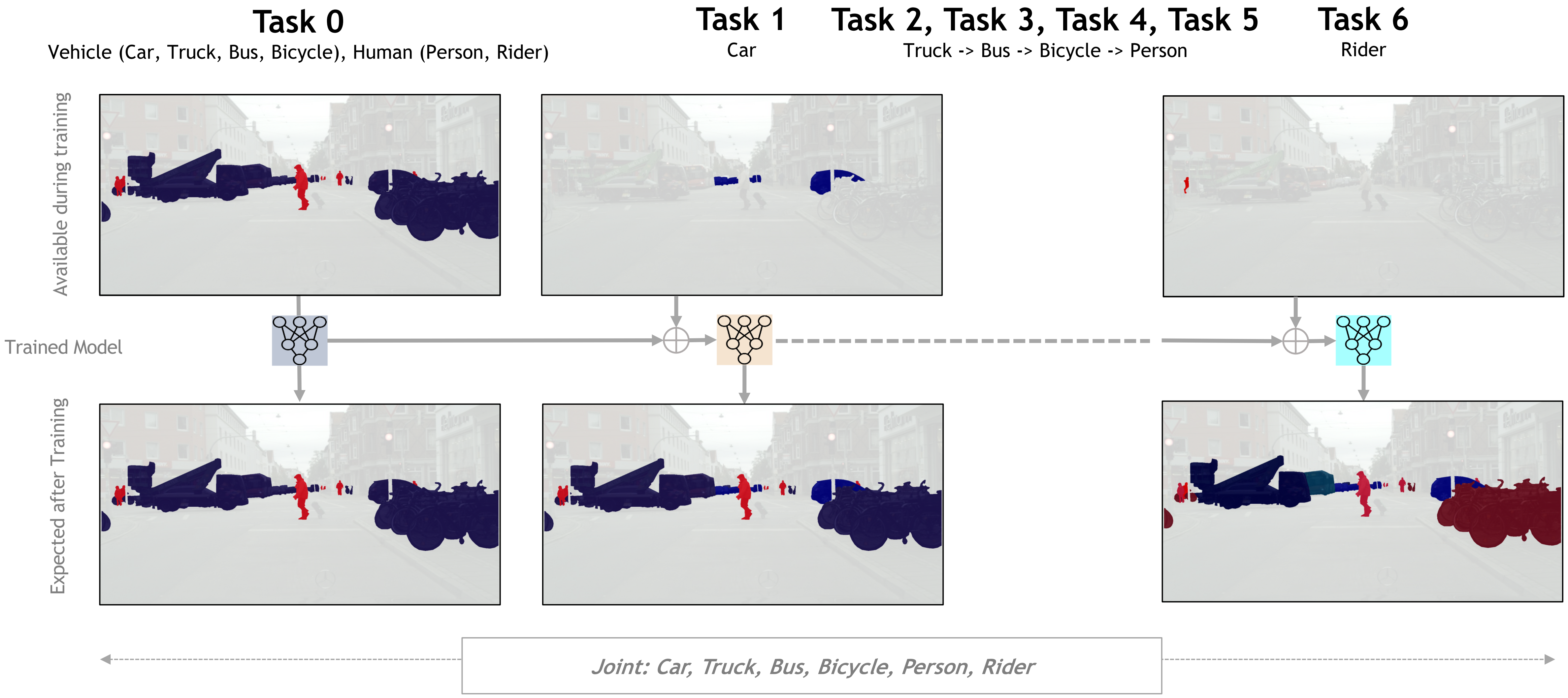
2

Experimental Design

Experiment 1: 2 Tasks



Experiment 2: 7 Tasks



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Results

Results: Joint Training

- **Experiment 1:** **2 Tasks**
  - Initial Task: Vehicle (Car, Truck, Bus), Human (Person, Rider)
  - (After) Final Task: Vehicle (Truck, Bus), Human (Person, Rider), Car, Bicycle

- **Experiment 2:** **7 Tasks**
  - Initial Task: Vehicle (Car, Truck, Bus, Bicycle), Human (Person, Rider)
  - (After) Final Task: Car, Truck, Bus, Bicycle, Person, Rider

ID	Class	IoU	
		Ex-1	Ex-2
0	background	98.4	98.4
12	person	-	63.9
13	rider	-	39.8
14	car	85.1	85.0
15	truck	-	58.1
16	bus	-	61.6
19	bicycle	54.8	55.3
20	Vehicle	61.2	-
21	Human	65.1	-
Joint	**mIoU**	**72.9**	**66.0**

Results: Naïve Training

Experiment 1:

		BG	Vehicle	Human	Car	Bicycle	mIoU
Initial Task →	**Task 0**	98.5	86.5	64.2	-	-	83.1
(After)Final Task →	**Task 1**	96.5	0.0	0.0	84.3	35.1	**43.2**
	Joint	*98.4*	*(61.2)*	*65.1*	*85.1*	*54.8*	***72.9***

Experiment 2:

		BG	Vehicle	Human	Car	Truck	Bus	Bicycle	Person	Rider	mIoU
Initial Task →	**Task 0**	98.4	84.0	64.8	-	-	-	-	-	-	82.4
	Task 1	96.3	0.0	0.0	83.7	-	-	-	-	-	45.0
	Task 2	92.3	0.0	0.0	0.0	34.4	-	-	-	-	25.1
	Task 3	92.4	0.0	0.0	0.0	0.0	36.2	-	-	-	21.4
	Task 4	92.2	-	0.0	0.0	0.0	0.0	49.2	-	-	23.6
	Task 5	92.8	-	0.0	0.0	0.0	0.0	0.0	61.0	-	25.6
(After)Final Task →	**Task 6**	92.0	-	-	0.0	0.0	0.0	0.0	0.0	11.1	**14.7**
	Joint	*98.4*	-	-	*85.0*	*58.1*	*61.6*	*55.3*	*63.9*	*39.8*	***66.0***

Results: MiB

Naïve	BG	Vehicle	Human	Car	Bicycle	mIoU
Task 0	98.5	86.5	64.2	-	-	83.1
Task 1	96.5	0.0	0.0	84.3	35.1	**43.2**
Joint	*98.4*	*(61.2)*	*65.1*	*85.1*	*54.8*	***72.9***

Experiment 1:

		BG	Vehicle	Human	Car	Bicycle	mIoU
Initial Task →	**Task 0**	98.5	86.5	64.2	-	-	83.1
(After)Final Task →	**Task 1**	98.0	11.3	64.0	0.0	1.9	**35.0**
	Joint	*98.4*	*(61.2)*	*65.1*	*85.1*	*54.8*	***72.9***

Naïve	BG	Vehicle	Human	Car	Truck	Bus	Bicycle	Person	Rider	mIoU
Task 0	98.4	84.0	64.8	-	-	-	-	-	-	82.4
Task 1	96.3	0.0	0.0	83.7	-	-	-	-	-	45.0
Task 2	92.3	0.0	0.0	0.0	34.4	-	-	-	-	25.1
Task 3	92.4	0.0	0.0	0.0	0.0	36.2	-	-	-	21.4
Task 4	92.2	-	0.0	0.0	0.0	0.0	49.2	-	-	23.6
Task 5	92.8	-	0.0	0.0	0.0	0.0	0.0	61.0	-	25.6
Task 6	92.0	-	-	0.0	0.0	0.0	0.0	0.0	11.1	**14.7**
Joint	*98.4*	-	-	*85.0*	*58.1*	*61.6*	*55.3*	*63.9*	*39.8*	***66.0***

Experiment 2:

		BG	Vehicle	Human	Car	Truck	Bus	Bicycle	Person	Rider	mIoU
Initial Task →	**Task 0**	98.4	84.0	64.8	-	-	-	-	-	-	82.4
	Task 1	98.3	15.9	64.4	1.5	-	-	-	-	-	45.0
	Task 2	98.3	11.4	64.1	0.8	0.0	-	-	-	-	34.9
	Task 3	98.1	6.1	64.1	0.5	0.0	0.0	-	-	-	28.1
	Task 4	98.1	-	63.7	0.3	0.0	0.0	0.0	-	-	27.0
	Task 5	98.1	-	10.1	0.2	0.0	0.0	0.0	19.4	-	18.3
(After)Final Task →	**Task 6**	98.0	-	-	0.1	0.0	0.0	0.0	22.9	0.0	**17.3**
	Joint	***98.4***	-	-	***85.0***	***58.1***	***61.6***	***55.3***	***63.9***	***39.8***	***66.0***

Results: Joint, Naïve & MiB

Experiment 1:

	mIoU
Joint (Upper Baseline)	**72.9**
Naïve	43.2
MiB	*35.0*

Experiment 2:

	mIoU
Joint (Upper Baseline)	**66.0**
Naïve	14.7
MiB	*17.3*

Visual Comparison: Experiment 1 (2 Tasks)

Image

Ground Truth

Joint Baseline – Predictions

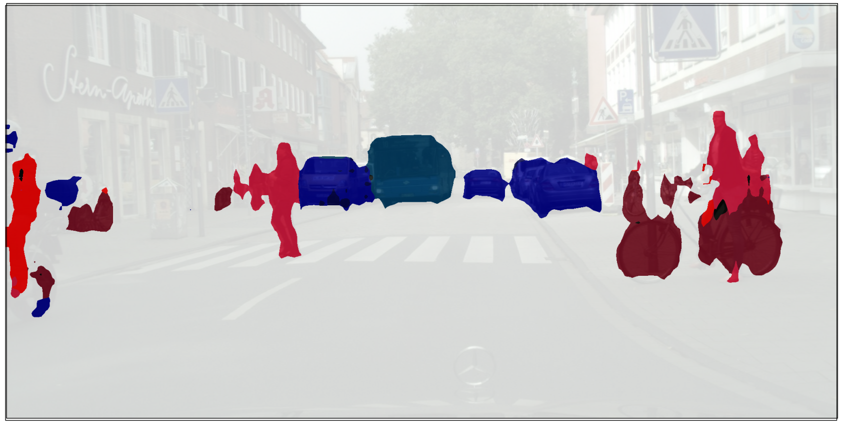
MiB - Predictions

Vehicles (Car, Truck, Bus), Humans (Person, Rider) $\longrightarrow$ Vehicles (Truck, Bus), Humans (Person, Rider), Car, Bicycle

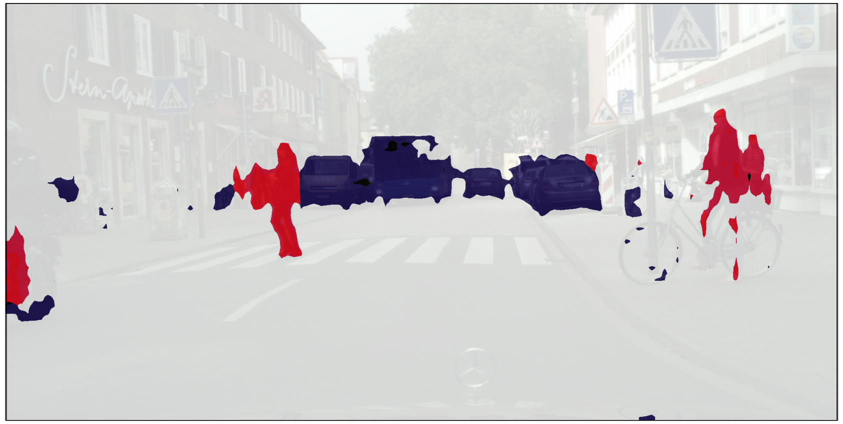
Visual Comparison: Experiment 2 (7 Tasks)

Image

Ground Truth



Joint Baseline – Predictions



MiB – Predictions

Vehicles (Car, Truck, Bus, Bicycle), Humans (Person, Rider) $\longrightarrow$ *Car, Truck, Bus, Bicycle, Person, Rider*

Summary & Conclusion

- Briefly presented the main concept of traditional Continual Learning (CL) for class incremental setting
- Showed the benchmarking results of two SoTA CL methods for Sem-Seg: MiB & PLOP
  - *MiB performed better than PLOP for the Cityscapes dataset*
- Introduced the new setting of CL where Label definitions can change over time (=ˆheterogeneous labels)
  - ***Heterogenous CL***
- Designed experimental settings for Heterogenous CL
- Evaluated MiB for Heterogenous CL scenarios

- ***Current SoTA can not cope with the redefinition of labels in incremental learning!***

KIDELTA LEARNING
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KI FAMILIE

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