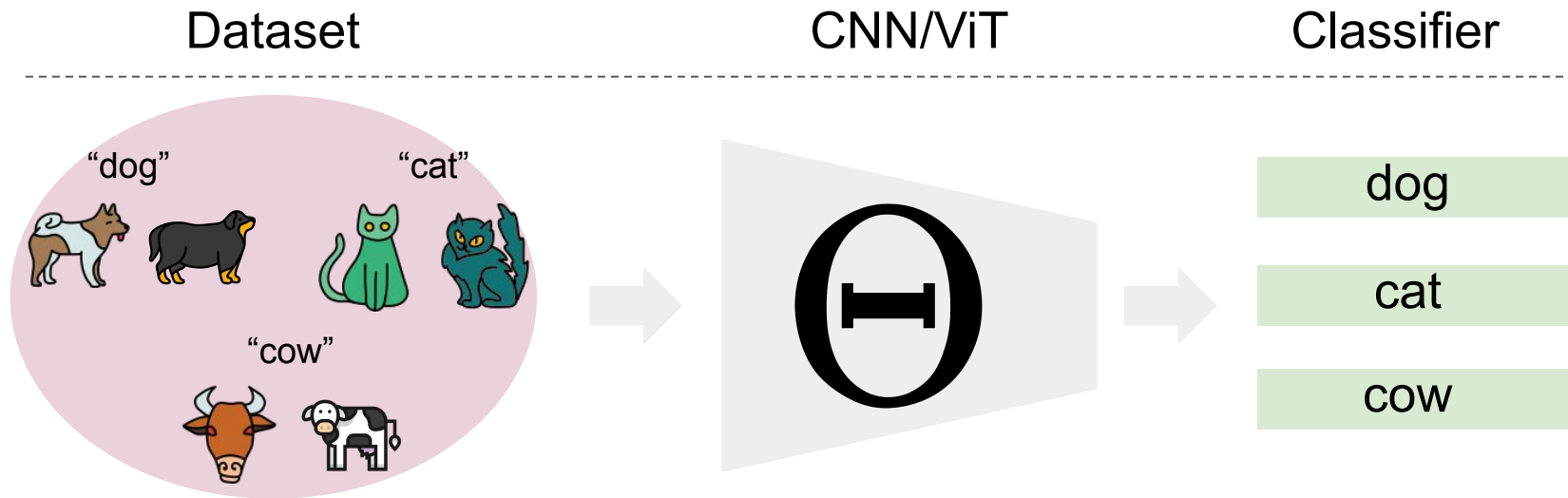


Towards Label-Efficient Incremental Learning

Mert Kilickaya, Joost van de Weijer, Yuki Asano

Eindhoven University of Technology
Autonomous University of Barcelona
University of Amsterdam

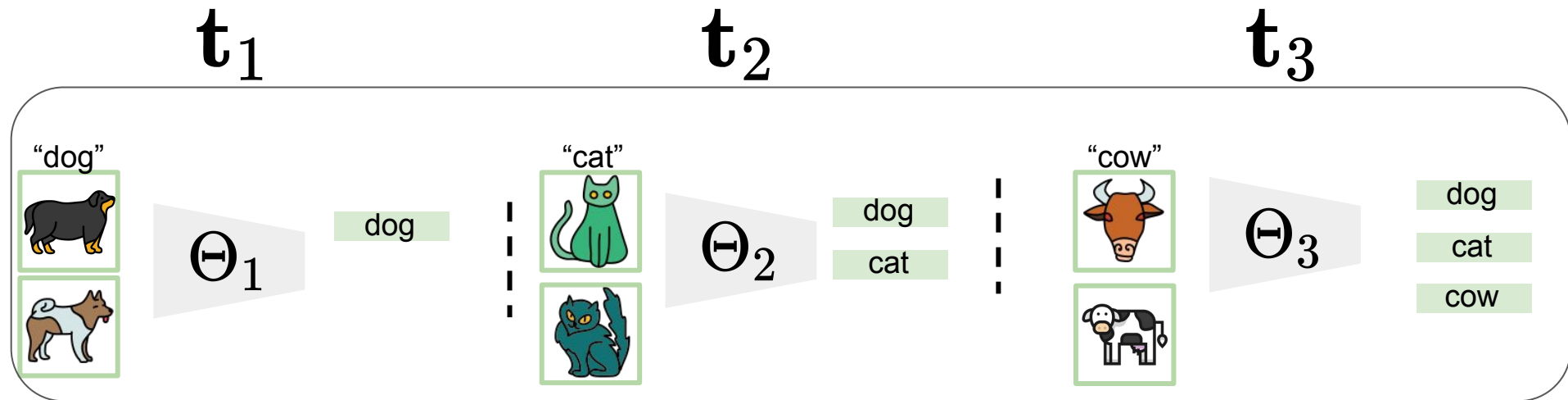
Batch Learning



✗ Static: Can't adapt & expand

✗ May Violate Privacy

Incremental Learning



Dynamic: Can adapt & expand

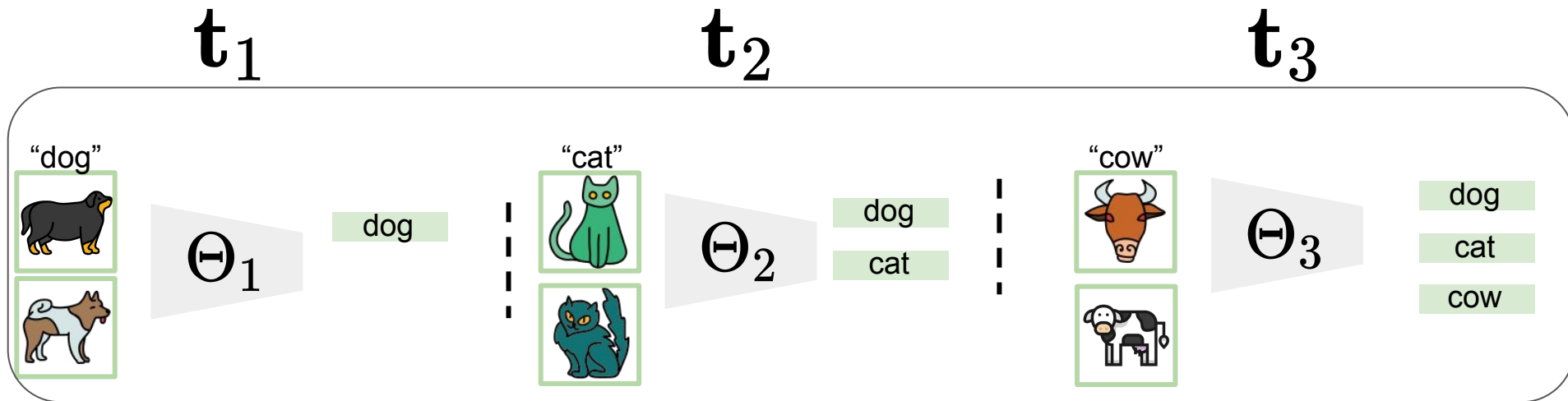


Forgetful: Past classes



Privacy-preserving

Incremental Learning is not Scalable



Dynamic: Can adapt & expand



Privacy-preserving



Forgetful: Past classes



Unscalable: Many-Labels

Towards Label-Efficient Incremental Learning

1

Semi-Supervision

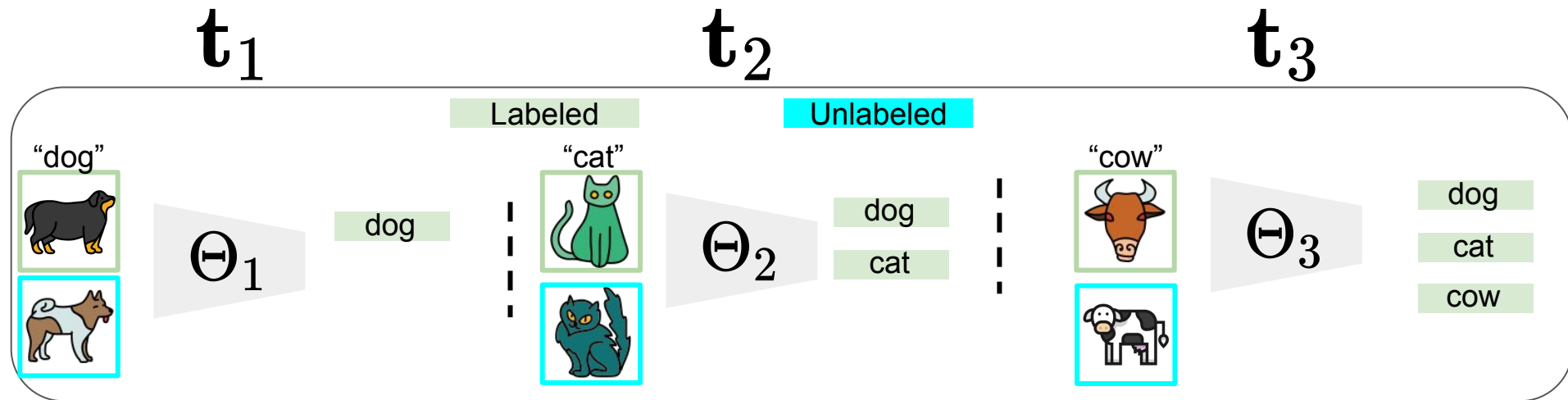
2

Few-shot-Supervision

3

Self-Supervision

Semi-Supervision for Incremental Learning



Perform self-training on unlabeled task data by leveraging labeled data.

1 Semi-Supervision for Incremental Learning

Labeled

Unlabeled

Within-data

Auxiliary-data

Test-data

train



“dog”

train



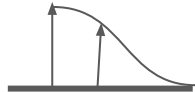
“dog”

train

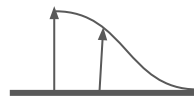


“dog”

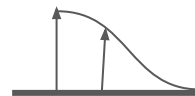
self-train



self-train



self-train

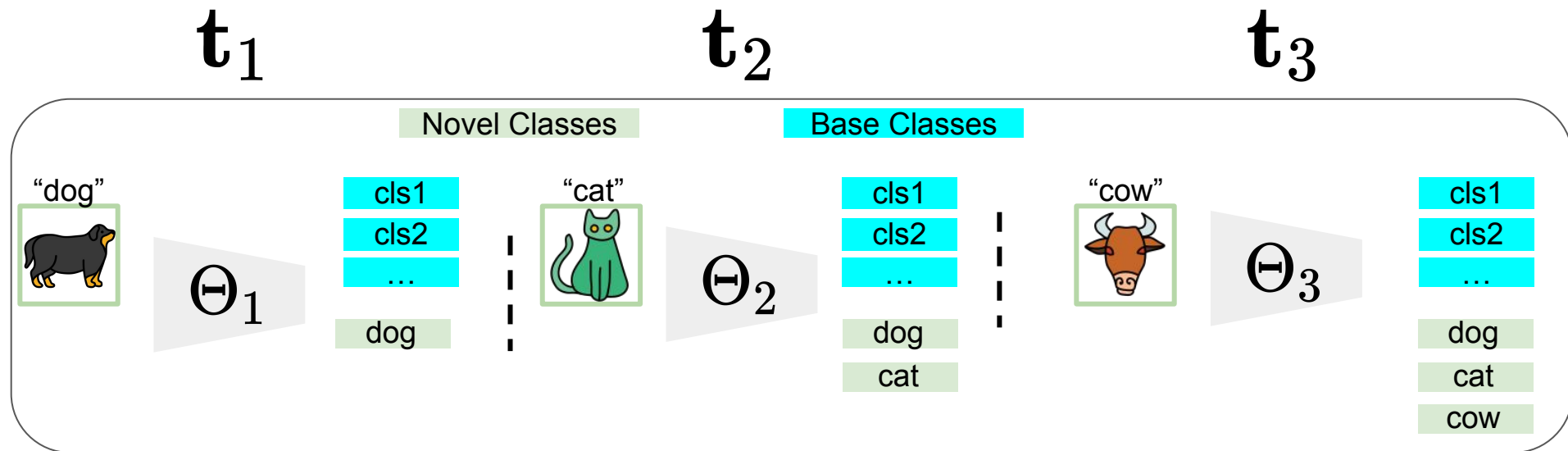


CNLL, 2017

DMC, 2020

CoTTA, 2022

Few-shot-Supervision for Incremental Learning



Learn to expand a pre-trained (base) category with novel classes with few examples (i.e. 1-shot)

Few-shot-Supervision for Incremental Learning

Novel Classes

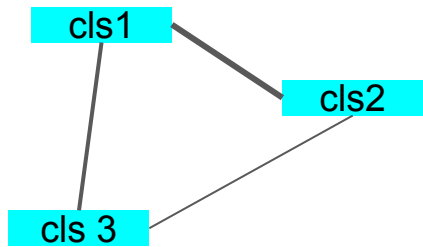
Base Classes

Graph-based

Clustering-based

Architectural-based

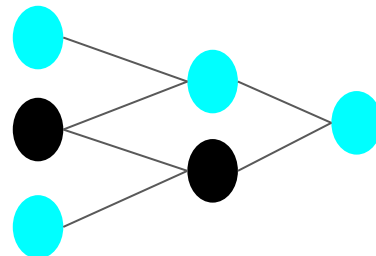
pre-train



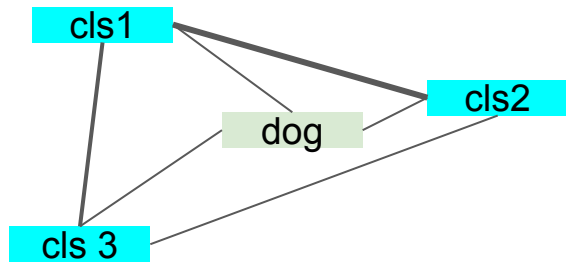
pre-train



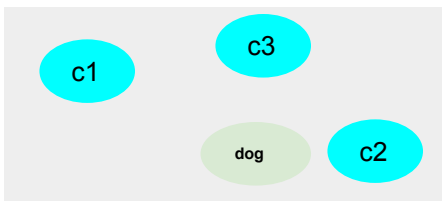
pre-train



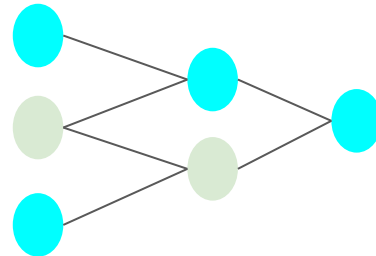
novel-train



novel-train



novel-train



TOPIC, 2020

IDL-VQ, 2020

FSLL, 2021

Self-Supervision for Incremental Learning

 t_1 t_2 t_3

View 1

View 2

 Θ_1 Θ_2 Θ_3 

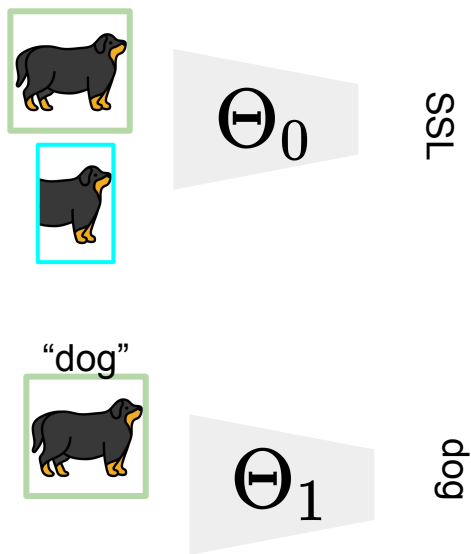
Pre-train a backbone via contrastively matching different image views (i.e. crop, rotation, color jitter)

Self-Supervision for Incremental Learning

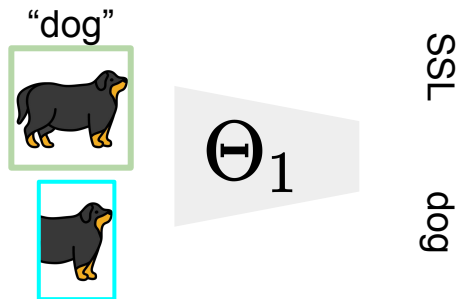
Pre-training

Auxiliary-training

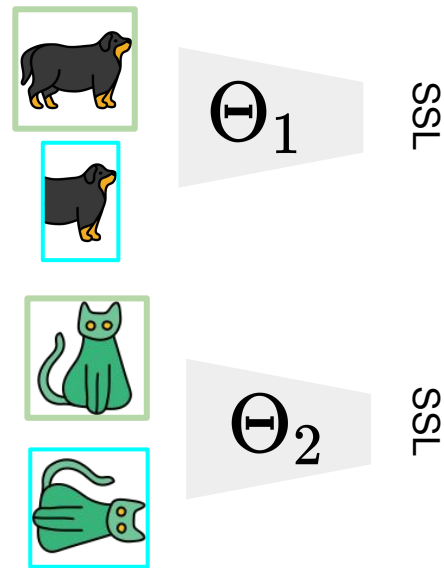
Main-training



SSL-OCL, 2021



PASS, 2021



CaSSLe, 2022

Summary: Overall

Settings	Subgroups	Supervision	Reference
Incremental Learning (IL)		Label-only	LwF [Li and Hoiem, 2017]
Semi-Supervised IL	Within-data	Pseudo & Label	CNLL [Baucum <i>et al.</i> , 2017]
	Auxiliary-data	Pseudo & Label	DMC [Zhang <i>et al.</i> , 2020]
	Test-data	Pseudo-only	CoTTA [Wang <i>et al.</i> , 2022]
Few-shot-Supervised IL	Graph-based	Label-only (Few)	TOPIC [Tao <i>et al.</i> , 2020]
	Clustering-based	Label-only (Few)	IDL-VQ [Chen and Lee, 2020]
	Architectural-based	Label-only (Few)	FSSL [Mazumder <i>et al.</i> , 2021]
Self-Supervised IL	Pre-training	Label-only	SSL-OCL [Gallardo <i>et al.</i> , 2021]
	Auxiliary-training	Self & Label	PASS [Zhu <i>et al.</i> , 2021]
	Main-training	Self-only	CaSSLe [Fini <i>et al.</i> , 2022]

Summary: Algorithms

Semi-Supervision

Algorithm	Data	Pre-training	Replayed Entity
CNNL	Within	✗	Pseudo-labels
DistillMatch	Within	✗	Pseudo-labels
ORDisCo	Within	✗	Pseudo-labels & Data
MetaCon	Within	✗	Pseudo-labels & Data
PGL	Within	✗	Pseudo-gradients
DMC	Auxiliary	✓	Pseudo-labels
CIL-QUD	Auxiliary	✓	Pseudo-labels
CoTTA	Test	✓	Pseudo-labels
NOTE	Test	✓	Data

Self-Supervision

Algorithm	Setting	Self-Supervision
SSL-OCL	Pre-training	MOCO/SwAV
PASS	Auxiliary-training	SLA
Buffer-SSL	Main-training	SimSiam
LUMP	Main-training	SimSiam/Barlow-Twins
CaSSLe	Main-training	SimCLR/Barlow-Twins/etc.
PFR	Main-training	Barlow-Twins

Few-shot-Supervision

Algorithm	Method	Regularization	Replay	Semantic
TOPIC	Graph	Anchor Loss	✗	✗
CEC	Graph	✗	✗	✗
IDL-VQ	Clustering	Center Loss	✓	✗
SA-KD	Clustering	✗	✓	✓
SUB-REG	Clustering	ℓ_1 Loss	✓	✓
FACT	Clustering	Augmentation	✗	✗
FSLL	Architectural	ℓ_1 Loss	✗	✗
C-FSCIL	Architectural	Orthogonal Loss	✓	✗

Limitations



Semi-Supervision:

Pseudo-supervision

Still many labeled examples

Few-shot-Supervision:

Only few-shots per-class

Requires large-scale pre-training

Self-Supervision:

No labels at train-time

Labels needed for evaluation

Future Directions

Incremental Dense Learning:

Continual object detection/segmentation, etc.

Incremental Active Learning:

Learning to select label-worthy exemplars.

Incremental Object Discovery:

Learn to recognize and discover novel objects.

~Thank you! Any questions?~