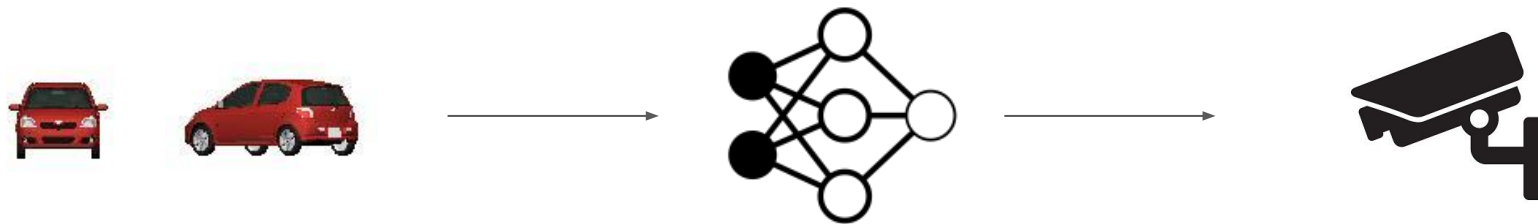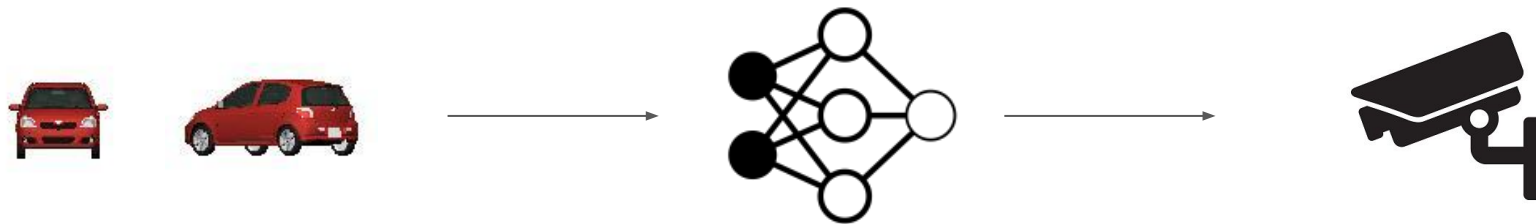# Continual Learning of Object Instances

Kishan Parshotam, Mert Kilickaya

Motivation
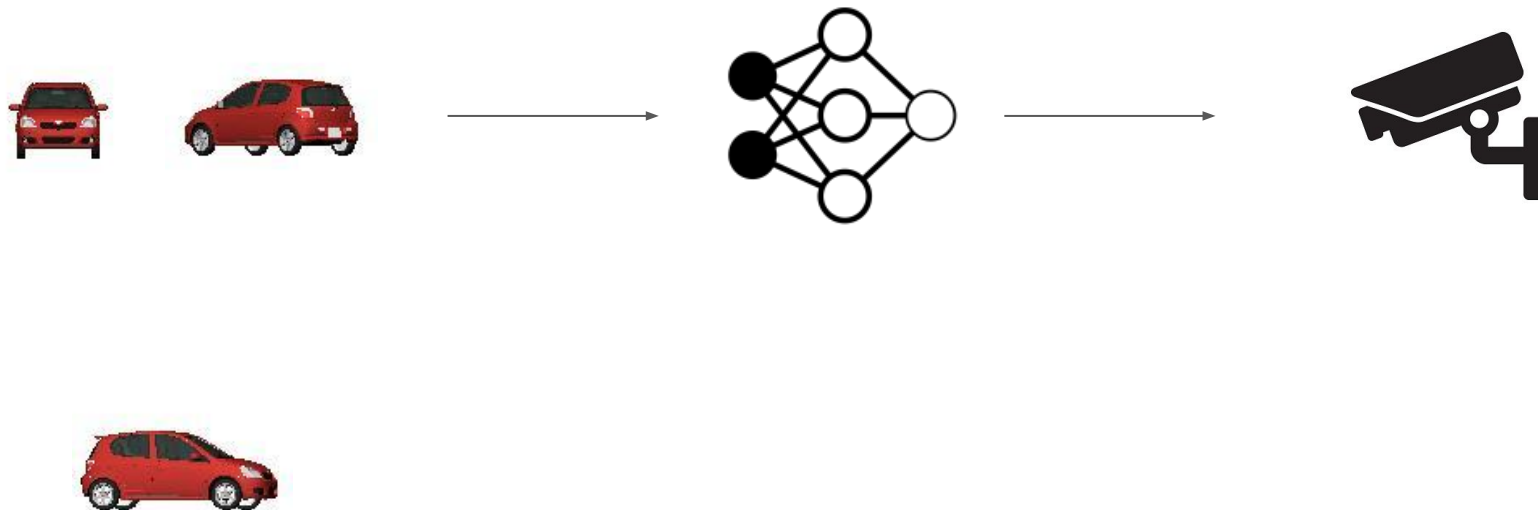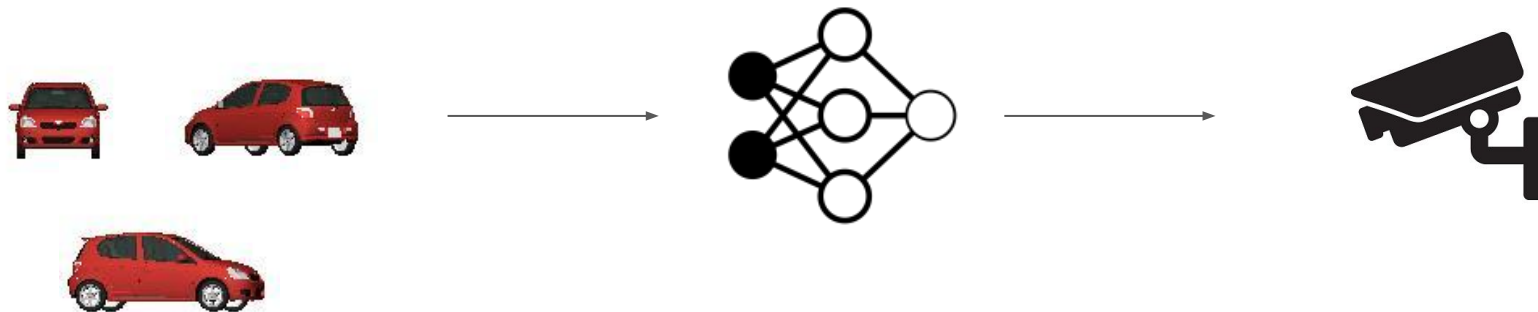
Motivation

Instance retrieval (Re-ID) with a predefined object of interest

Motivation

Motivation

Motivation

Data privacy
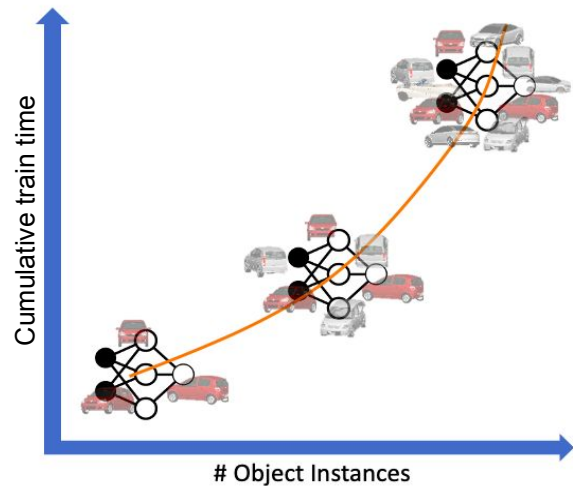
Training Complexity

How can we continually learn to recognise object instances?

Motivation
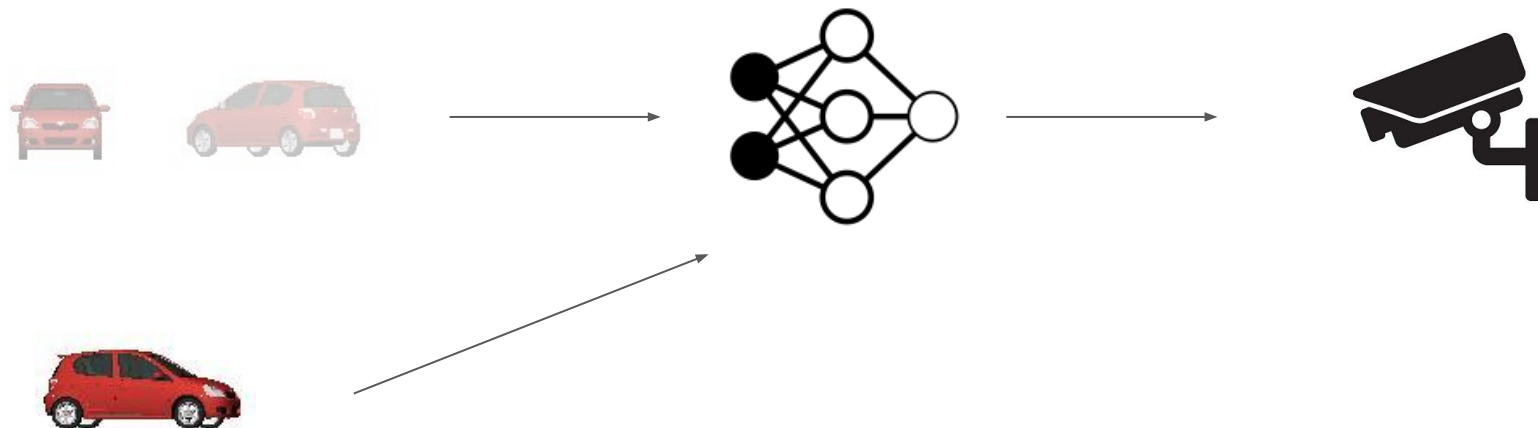
Continual Instance Learning

Catastrophic Forgetting

Continual Instance Learning Literature

Continual Learning

Mainly consider classification tasks

Does not consider metric learning for *new instances*

Metric Learning

Cannot be directly integrated in CL

Unbounded regression loss

Continual sets have limited samples

Continual Instance Learning RQ's

RQ1 - Can we evaluate existing continual learning techniques for instance retrieval?

RQ1 - Approach

Continual Learning (CL) meets Metric Learning

1. Naive

2. FineTune

3. LFL ⟹ Knowledge Distillation

4. LWF

5. EWC ⟹ Weight importance
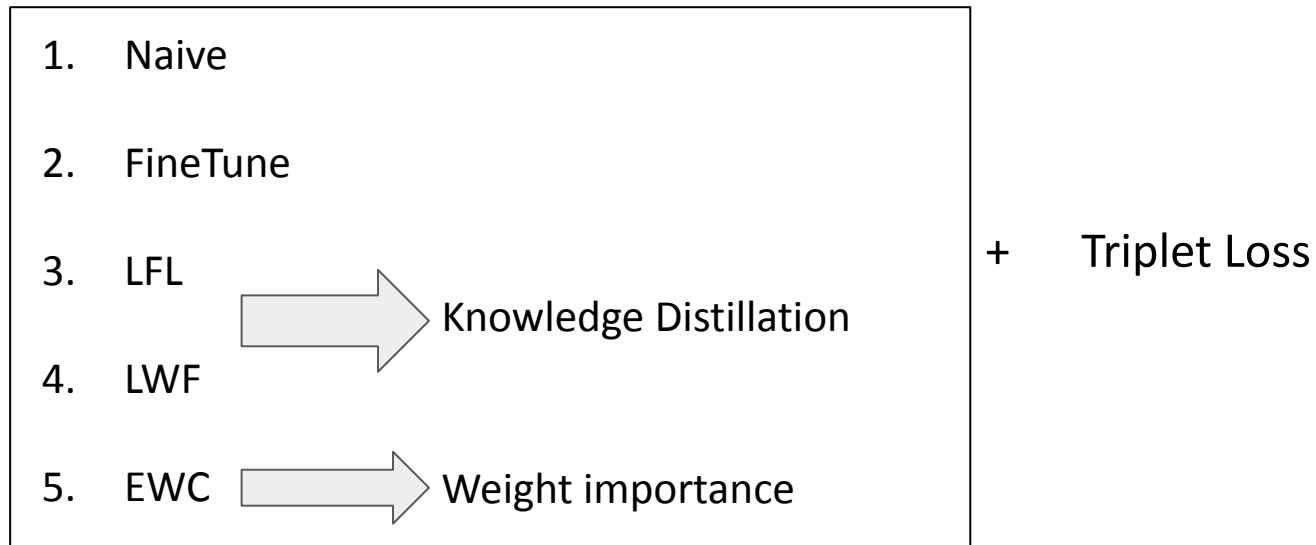
\+ Triplet Loss

Replace cross-entropy loss with triplet loss

Experimental Setup

Cars3D

MVCD

CompCars

Train: 100 instances, 10 batches	Train: 15 instances, 5 batches	Train: 240 instances, 10 batches
Test: 83 instances	Test: 5 instances	Test: 41 instances

Backbones

- LeNet-5
- ResNet-18

Evaluation

- Mean Average Precision (mAP)
- Forget (Δ mAP / Offline mAP)

Exp1 - How do CL techniques perform in instance retrieval?

Dataset	Approach	LeNet			ResNet		
		Offline(%)	mAP(%↑)	Forget(%↓)	Offline(%)	mAP(%↑)	Forget(%↓)
Cars3D	Naïve	68.69	46.28	32.89	70.82	50.01	29.38
	FT	68.69	**49.36**	**28.43**	70.82	44.98	36.49
	LFL	68.69	33.05	52.08	70.82	33.96	52.05
	LwF	68.69	–	–	70.82	–	–
	EWC	68.69	46.19	33.02	70.82	**50.91**	**28.11**
MVCD	Naïve	83.22	62.31	25.13	94.99	**83.77**	**11.81**
	FT	83.22	60.65	27.13	94.99	72.75	23.41
	LFL	83.22	**62.86**	**24.47**	94.99	66.24	30.27
	LwF	83.22	–	–	94.99	–	–
	EWC	83.22	61.44	26.18	94.99	81.44	14.26
CompCars	Naïve	29.83	**18.25**	**38.82**	54.41	**38.60**	**29.06**
	FT	29.83	12.51	58.06	54.41	22.63	58.41
	LFL	29.83	11.18	62.52	54.41	25.24	53.61
	LwF	29.83	–	–	54.41	–	–
	EWC	29.83	17.19	42.37	54.41	37.43	31.21

Current CL approaches forget

Current CL approaches do not outperform a naive approach

Continual Instance Learning RQ's

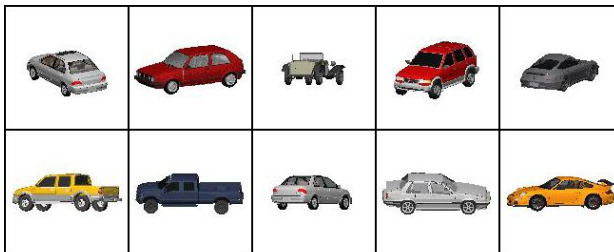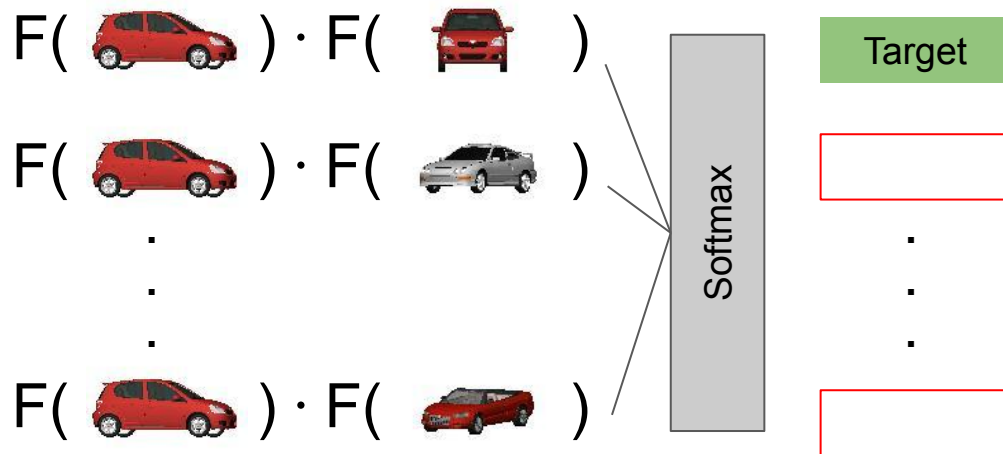RQ1 - Can we evaluate existing continual learning techniques for instance retrieval? Yes.

RQ2 - Can we represent continual instance learning as a classification problem?

RQ2 - Approach

Incorporate *normalised cross-entropy* (NCE)

Allows integration with CL approaches

Robust to outliers

Exp2 - Does normalised cross-entropy help CIL?

Dataset	Approach	LeNet Regression(%↓)	LeNet w/ NCE(%↓)	ResNet Regression(%↓)	ResNet w/ NCE(%↓)
Cars3D	Naïve	32.89	25.64	29.38	30.61
	FT	28.43	24.02	36.49	33.71
	LFL	52.08	33.50	52.05	43.10
	LwF	–	**18.29**	–	30.19
	EWC	33.02	23.66	28.11	**19.87**
MVCD	Naïve	25.13	22.80	**11.81**	16.10
	FT	27.13	**20.37**	23.41	24.16
	LFL	24.47	20.76	30.27	27.11
	LwF	–	21.36	–	14.59
	EWC	26.18	28.44	14.26	13.92
CompCars	Naïve	38.82	35.13	**29.06**	39.77
	FT	58.06	51.66	58.41	52.38
	LFL	62.52	58.26	53.61	54.47
	LwF	–	49.55	–	60.37
	EWC	42.37	**32.28**	31.21	29.13

NCE helps current CL approaches

Allows integration with CL approaches

Continual Instance Learning RQ's

RQ1 - Can we evaluate existing continual learning techniques for instance retrieval? Yes.

RQ2 - Can we represent continual instance learning as a classification problem? Yes.

RQ3 - Can we leverage synthetic visual data to improve continual instance learning?

RQ3 - Approach

Synthetic data are accessible and benefit from labels

1. Pre-train a model on synthetic data (Cars3D).

2. Apply continual learning on real-data.

Pre-training of fine-grained representations

Exp3 - Does synthetic transfer help CIL?

		LeNet		ResNet	
Dataset	Approach	Regression(% ↓)	w/NCE+Transfer(%↓)	Regression(% ↓)	w/NCE+Transfer(%↓)
MVCD	Naïve	25.13	9.84	11.81	**0.48**
	FT	27.13	10.15	23.41	19.23
	LFL	24.47	14.25	30.27	13.16
	LwF	–	**3.08**	–	12.12
	EWC	26.18	9.22	14.26	2.29
CompCars	Naïve	38.82	**37.85**	**29.06**	33.82
	FT	58.06	71.74	58.41	70.99
	LFL	62.52	61.28	53.61	50.01
	LwF	–	60.44	–	41.15
	EWC	42.37	39.73	31.21	31.35

Reduces forgetting when the synthetic data is comparable to the real data

Retrieval examples
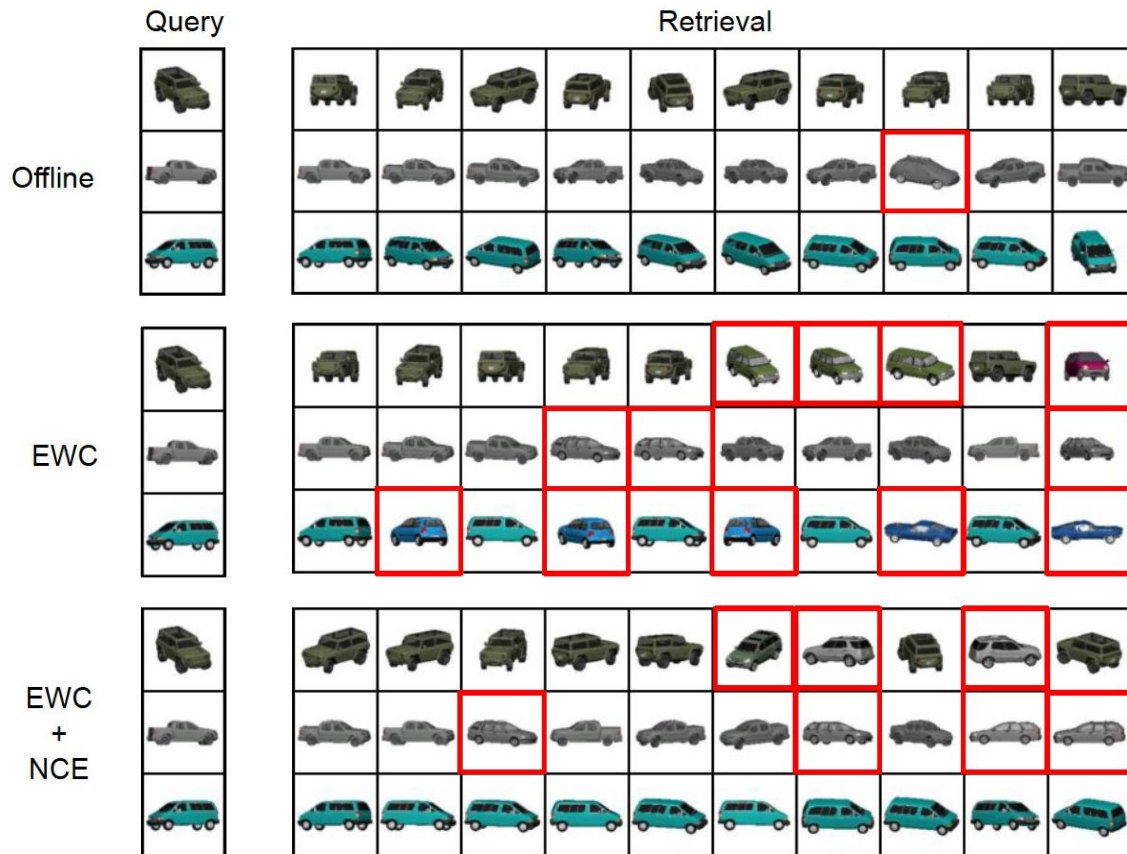
Conclusion

Current CL approaches forget in *instance retrieval* tasks

Current CL approaches do not outperform a naive approach

NCE helps forgetting less

Synthetic transfer reduces forgetting under comparable data setups

Limitations & Future Work

Limited continual batches

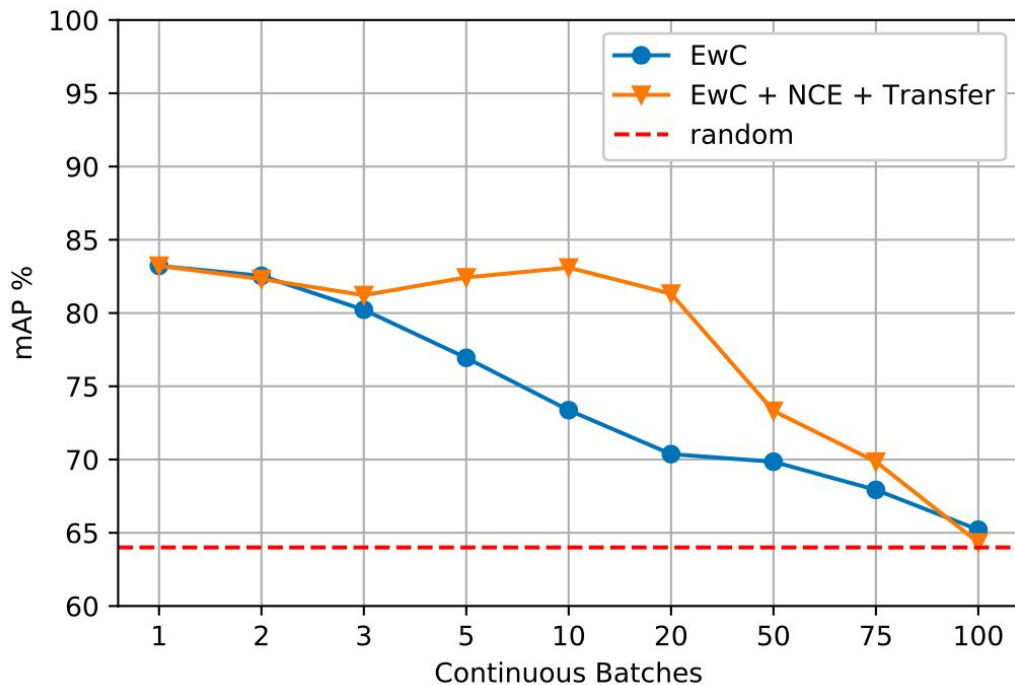No backward-compatibility

Extension to other objects

Extension to other CL approaches (replay, architectural)

Thank You

Code: https://github.com/ProsusAI/continual-object-instances

Appendix

Continual Batch Session Length

Our approach is more robust to a higher number of *continual batches*