Incremental False Negative Detection for Contrastive Learning

Tsai-Shien Chen[1], **Wei-Chih Hung**[2], **Hung-Yu Tseng**[3], **Shao-Yi Chien**[1], **Ming-Hsuan Yang**[3,4,5]

[1] National Taiwan University
[2] Waymo LLC
[3] University of California, Merced
[4] Yonsei University
[5] Google Research

Problems of False Negatives
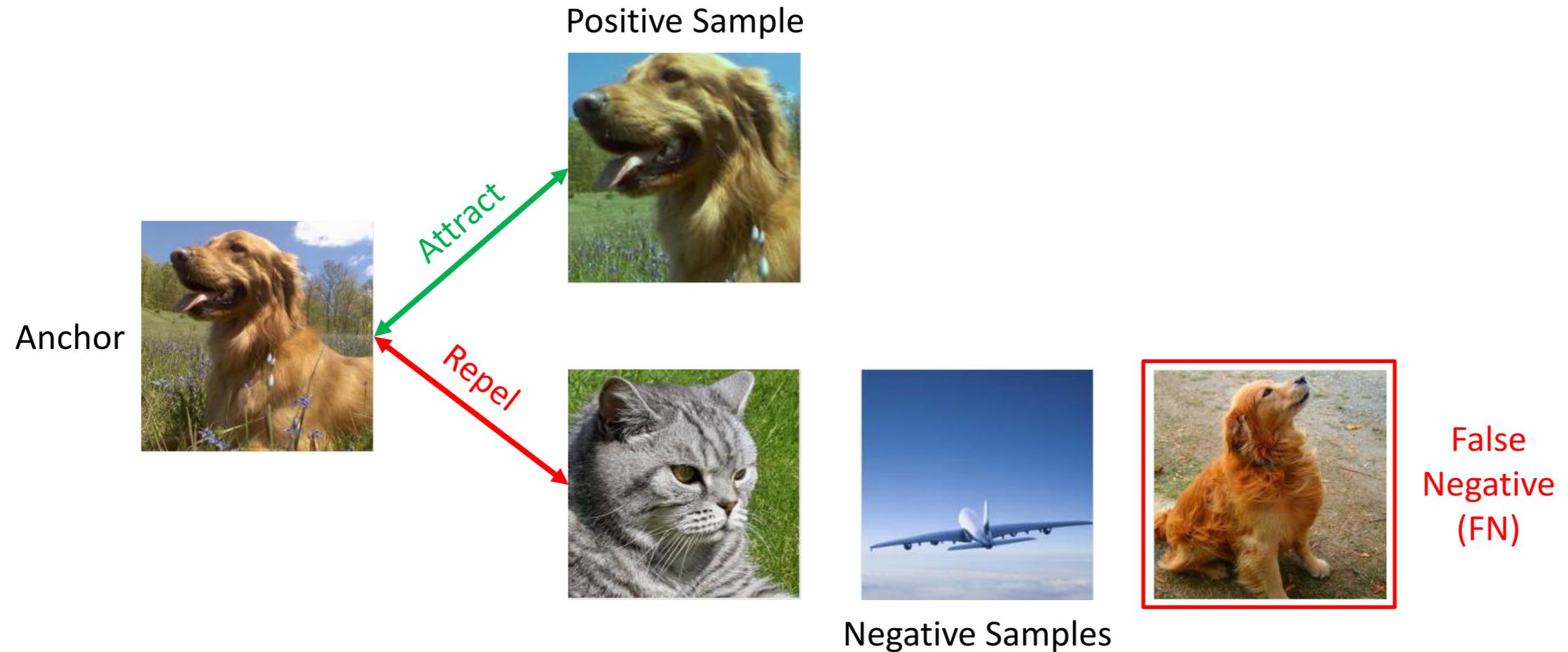
Problems of False Negatives

- Experiment:

  – Comparing models:
  SimCLR[1], SupCon[2]
  Trains with FN   Trains without FN

  – Dataset: ImageNet
  with re-defined
  coarse to fine labels

  *More classes = Minor effects
  of the false negatives?*
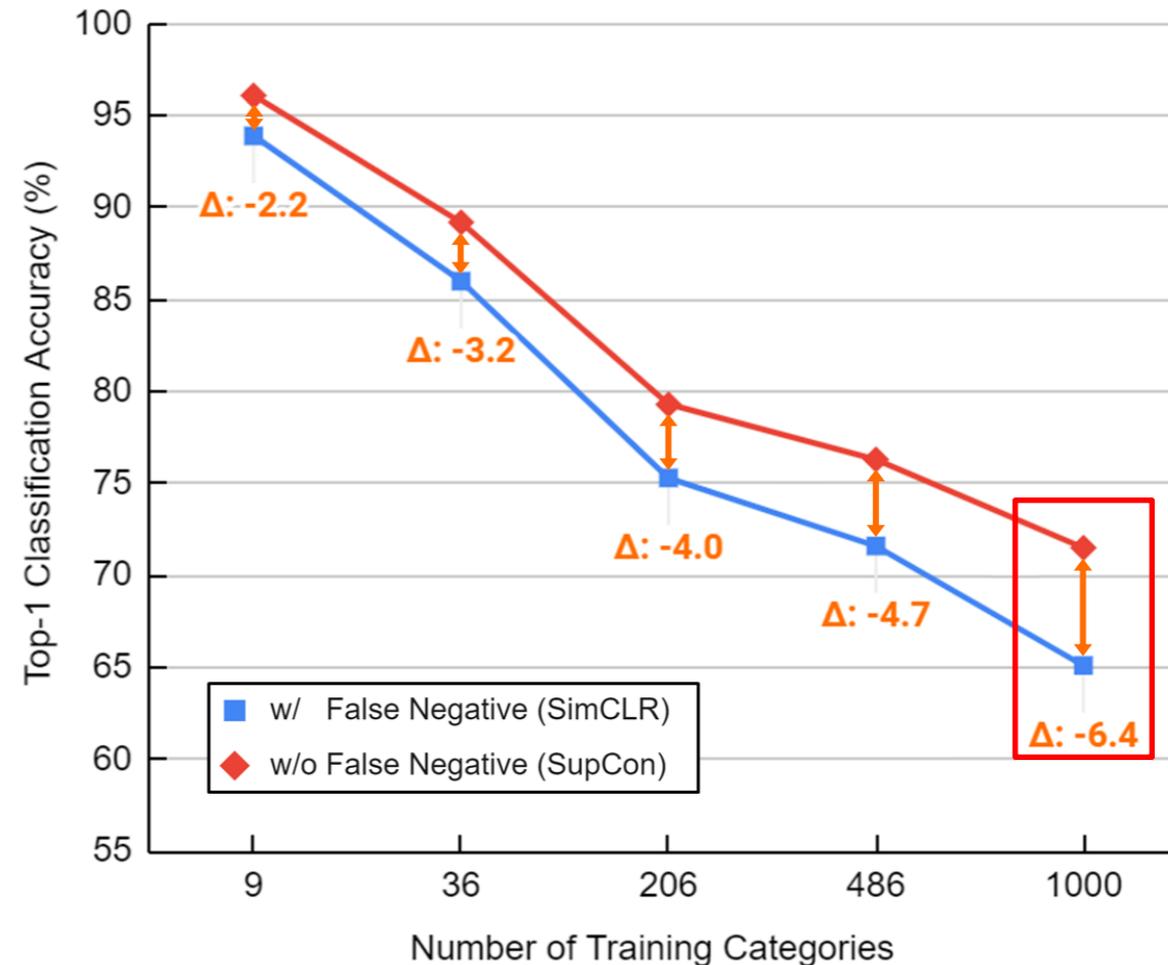
[1] T. Chen et al., "*A Simple Framework for Contrastive Learning of Visual Representations*", ICML 2020
[2] P. Khosla et al., "*Supervised Contrastive Learning*", NeurIPS 2020

Incremental False Negative Detection

- Part 1: How to detect false negatives?

Ground Truth Label

Pseudo Label

100th epoch   500th epoch   1000th epoch
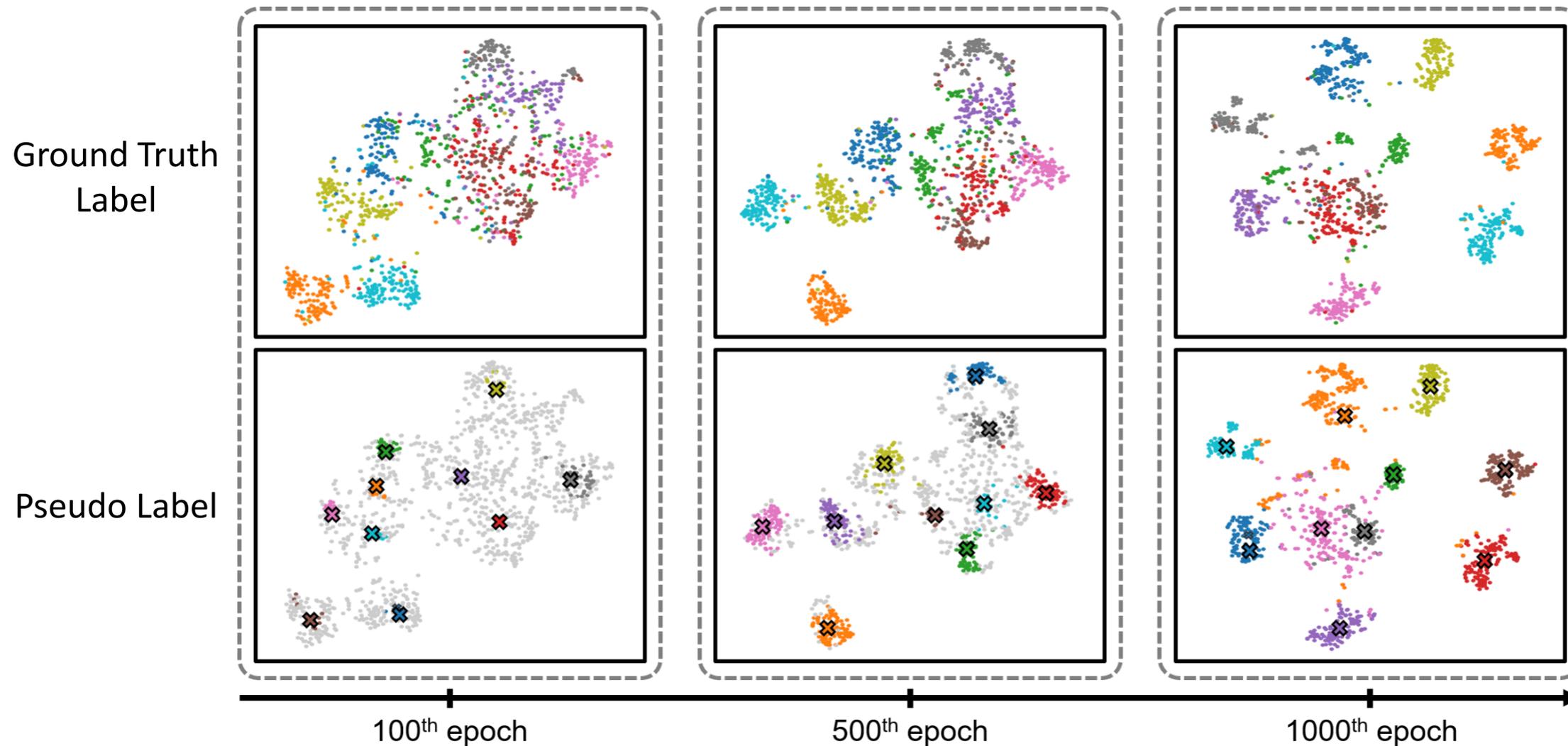
Incremental False Negative Detection

- Part 2: How to remove the detected false negatives?

- Strategy 1: directly eliminate false negatives

$$\mathcal{L}_{elim} = \sum_{i \in \mathcal{I}} -\log \frac{\text{sim}(\boldsymbol{z}_i, \boldsymbol{z}_{i'})}{\sum_{s \in \mathcal{S}(i)} \text{sim}(\boldsymbol{z}_i, \boldsymbol{z}_s)}, \quad \mathcal{S}(i) \equiv \{i', n \mid n \in \mathcal{N}(i), y_n \neq y_i\}$$

- Strategy 2: treat false negatives as positives

$$\mathcal{L}_{attr} = \sum_{i \in \mathcal{I}} \frac{1}{|\mathcal{P}(i)|} \sum_{p \in \mathcal{P}(i)} -\log \frac{\text{sim}(\boldsymbol{z}_i, \boldsymbol{z}_p)}{\sum_{s \in \mathcal{S}(i)} \text{sim}(\boldsymbol{z}_i, \boldsymbol{z}_s)}, \quad \begin{cases} \mathcal{S}(i) \equiv \{i', n \mid n \in \mathcal{N}(i)\} \\ \mathcal{P}(i) \equiv \{i', n \mid n \in \mathcal{N}(i), y_n = y_i\} \end{cases}$$

Experiments

- Linear evaluation and transfer learning on three benchmarks

Method	Architecture	Pre-training		Datasets		
		batchsize	epochs	ImageNet	VOC	Places
Jigsaw (Noroozi & Favaro, 2016)	AlexNet	256	-	34.6	67.6	-
Rotation (Gidaris et al., 2018)	AlexNet	128	100	38.7	73.0	35.1
DeepCluster (Caron et al., 2018)	AlexNet	256	500	41.0	73.7	39.8
InstDisc (Wu et al., 2018)	ResNet-50	256	200	54.0	-	45.5
LocalAgg (Zhuang et al., 2019)	ResNet-50	128	200	60.2	-	50.1
CMC (Tian et al., 2019)	ResNet-50	-	200	66.2	-	-
SimCLR (Chen et al., 2020b)	ResNet-50	256	200	64.3	-	-
MoCo (He et al., 2020)	ResNet-50	256	200	60.6	79.2	48.9
MoCo v2 (Chen et al., 2020d)	ResNet-50	256	200	67.5	84.0	50.1
PCL (Li et al., 2021)	ResNet-50	256	200	67.6	85.4	50.3
IFND (Ours)	ResNet-50	256	200	**69.7**	**87.3**	**51.9**
CPC (Oord et al., 2018)	ResNet-101	512	-	48.7	-	-
SeLa (Asano et al., 2020)	ResNet-50	1024	400	61.5	-	-
PIRL (Misra & Maaten, 2020)	ResNet-50	1024	800	63.6	81.8	49.8
SimCLR (Chen et al., 2020b)	ResNet-50	4096	1000	69.3	-	-
BYOL (Grill et al., 2020)	ResNet-50	4096	1000	74.3	-	-
SwAV (Caron et al., 2020)	ResNet-50	4096	800	75.3	88.9	56.7

Experiments

- Semi-supervised learning on ImageNet

Method	Architecture	Pre-training		Label fraction	
		batchsize	epochs	1%	10%
InstDisc (Wu et al., 2018)	ResNet-50	256	120	39.2	77.4
MoCo (He et al., 2020)	ResNet-50	256	200	56.9	83.0
MoCo v2 (Chen et al., 2020d)	ResNet-50	256	200	66.3	84.4
PCL (Li et al., 2021)	ResNet-50	256	200	75.3	85.6
IFND (Ours)	ResNet-50	256	200	**77.0**	**86.5**
S4L(MOAM) (Zhai et al., 2019)	ResNet-50 (4×)	256	1000	-	91.2
PIRL (Misra & Maaten, 2020)	ResNet-50	1024	800	57.2	83.8
SimCLR (Chen et al., 2020b)	ResNet-50	4096	1000	75.5	87.8
BYOL (Grill et al., 2020)	ResNet-50	4096	1000	78.4	89.0
SwAV (Caron et al., 2020)	ResNet-50	4096	800	78.5	89.9

Experiments

- Object detection and instance segmentation on COCO

Method	AP^{bb}	AP^{bb}_{50}	AP^{bb}_{75}	AP^{mk}	AP^{mk}_{50}	AP^{mk}_{75}
Supervise	40.0	59.9	43.1	34.7	56.5	36.9
MoCo (He et al., 2020)	40.7	60.5	44.1	35.4	57.3	37.6
PCL (Li et al., 2021)	41.0	60.8	44.2	35.6	57.4	37.8
IFND (Ours)	**41.8**	**61.2**	**44.5**	**36.1**	**57.6**	**38.5**

- Clustering quality on ImageNet

Method	NMI
DeepCluster (Caron et al., 2018)	43.2 ± 2.9
MoCo v2 (Chen et al., 2020d)	57.9 ± 2.2
SwAV (Caron et al., 2020)	63.8 ± 1.6
PCL (Li et al., 2021)	65.0 ± 1.9
IFND (Ours)	$\mathbf{67.5} \pm 1.7$