Fine-grained Classes and How to Find Them?

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Motivation

Easy to get and often available
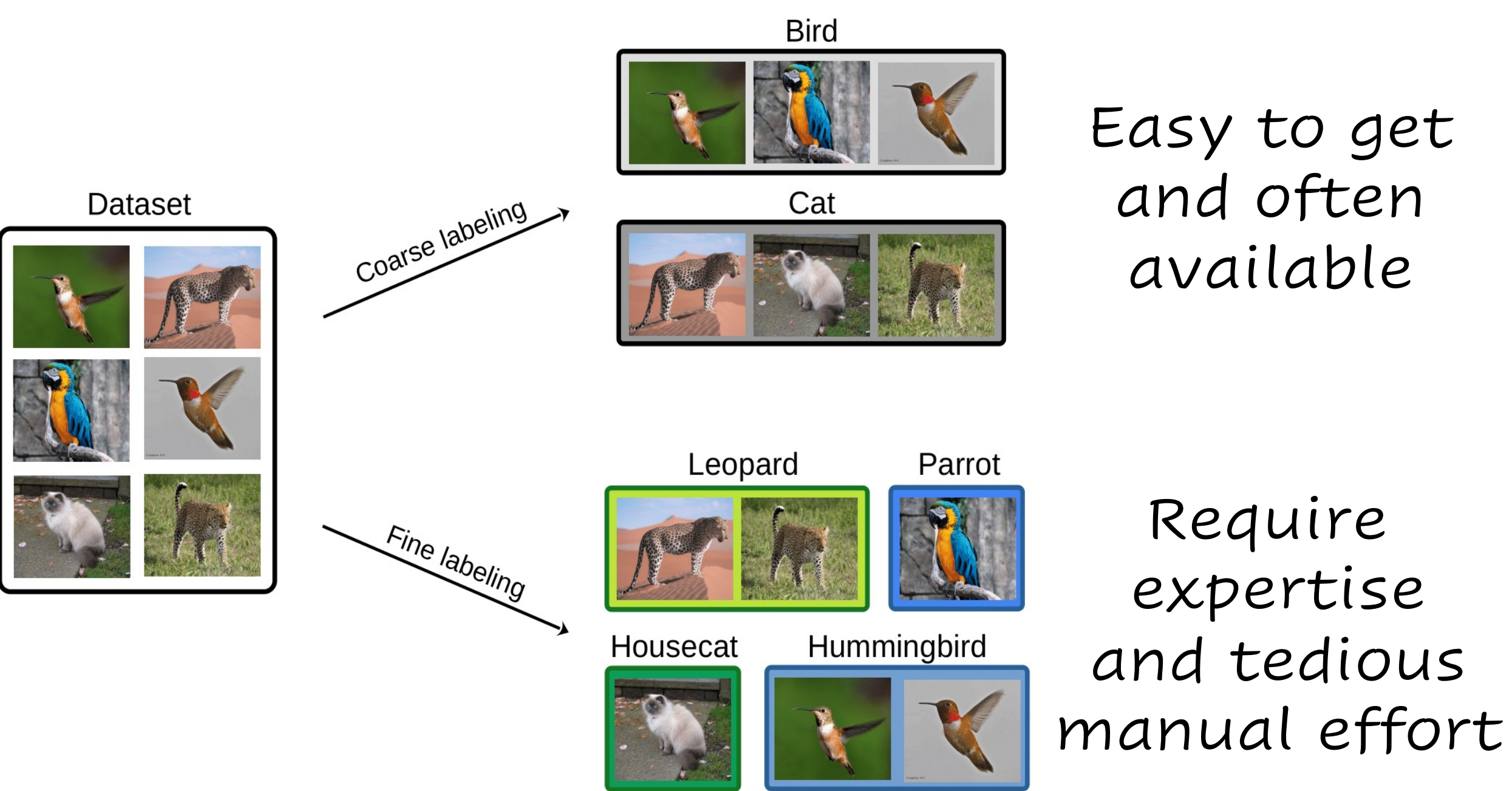
Require expertise and tedious manual effort

Can we discover fine-grained classes in coarsely labeled data?

Class relations form bipartite graph
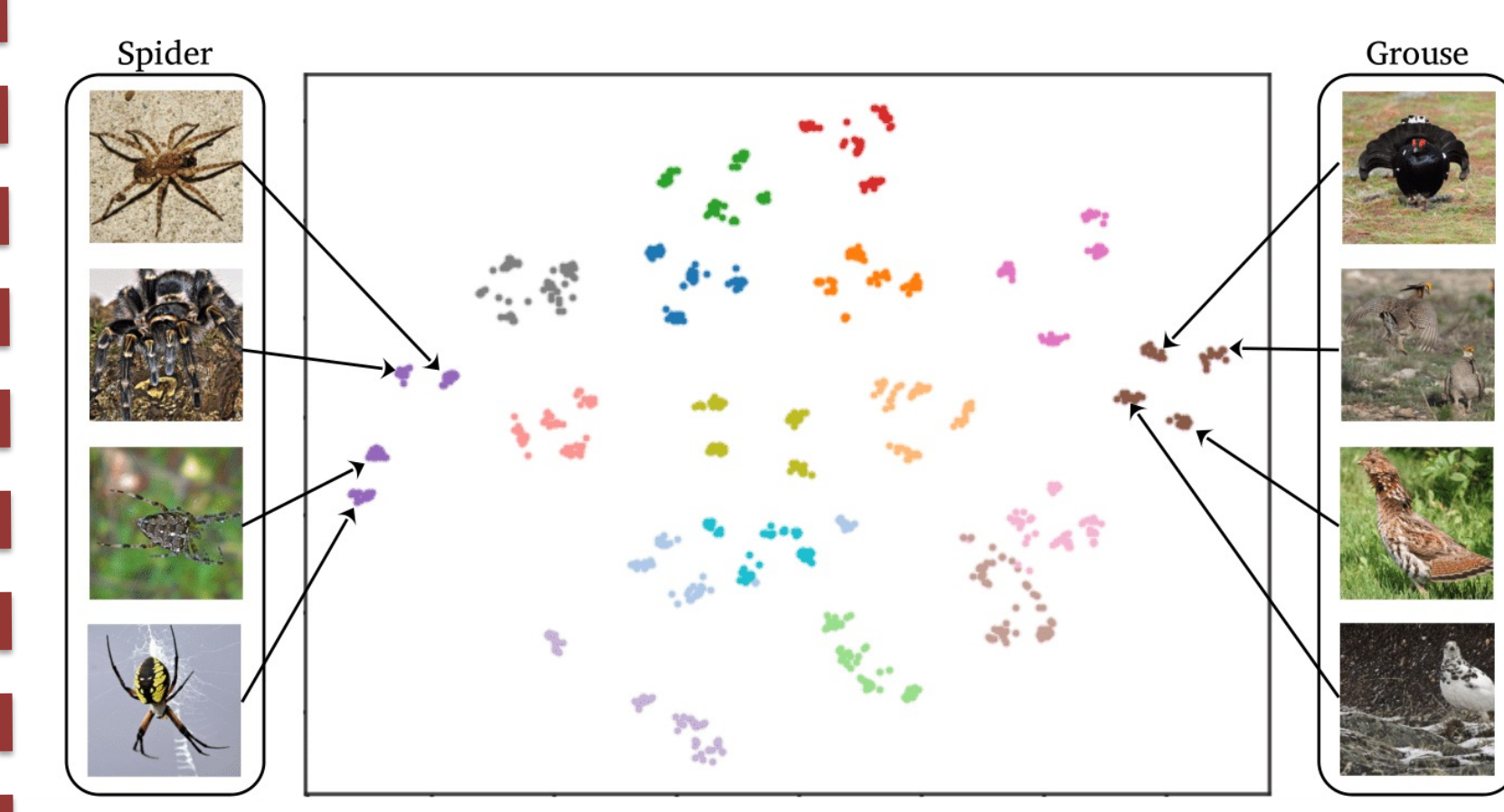
Discovered fine-grained classes

Available coarse-grained classes
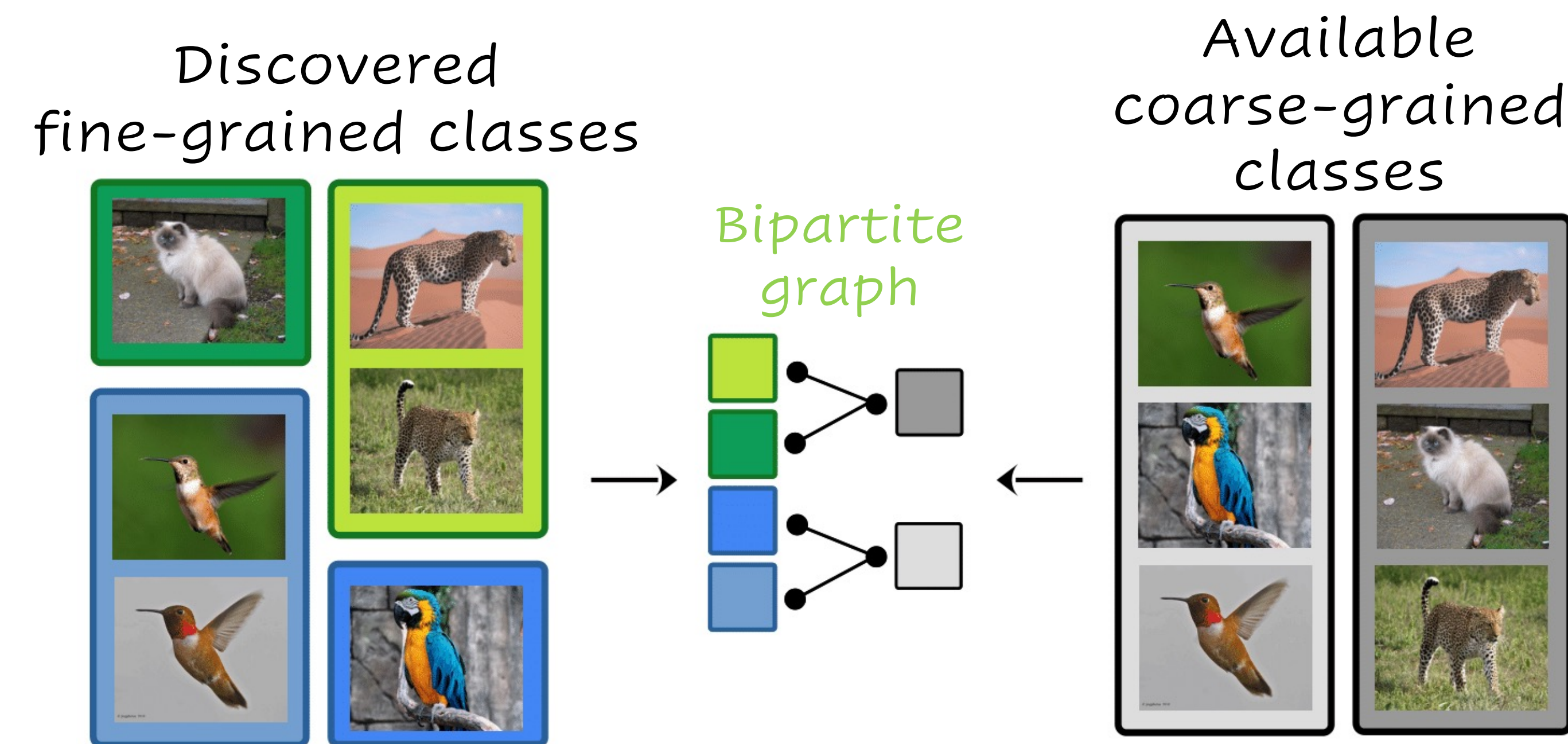
Bipartite graph

Key observation: relations between coarse and fine classes form **a bipartite graph.**

Results

Coarse class: **Salamander**   Coarse class: **Bear**
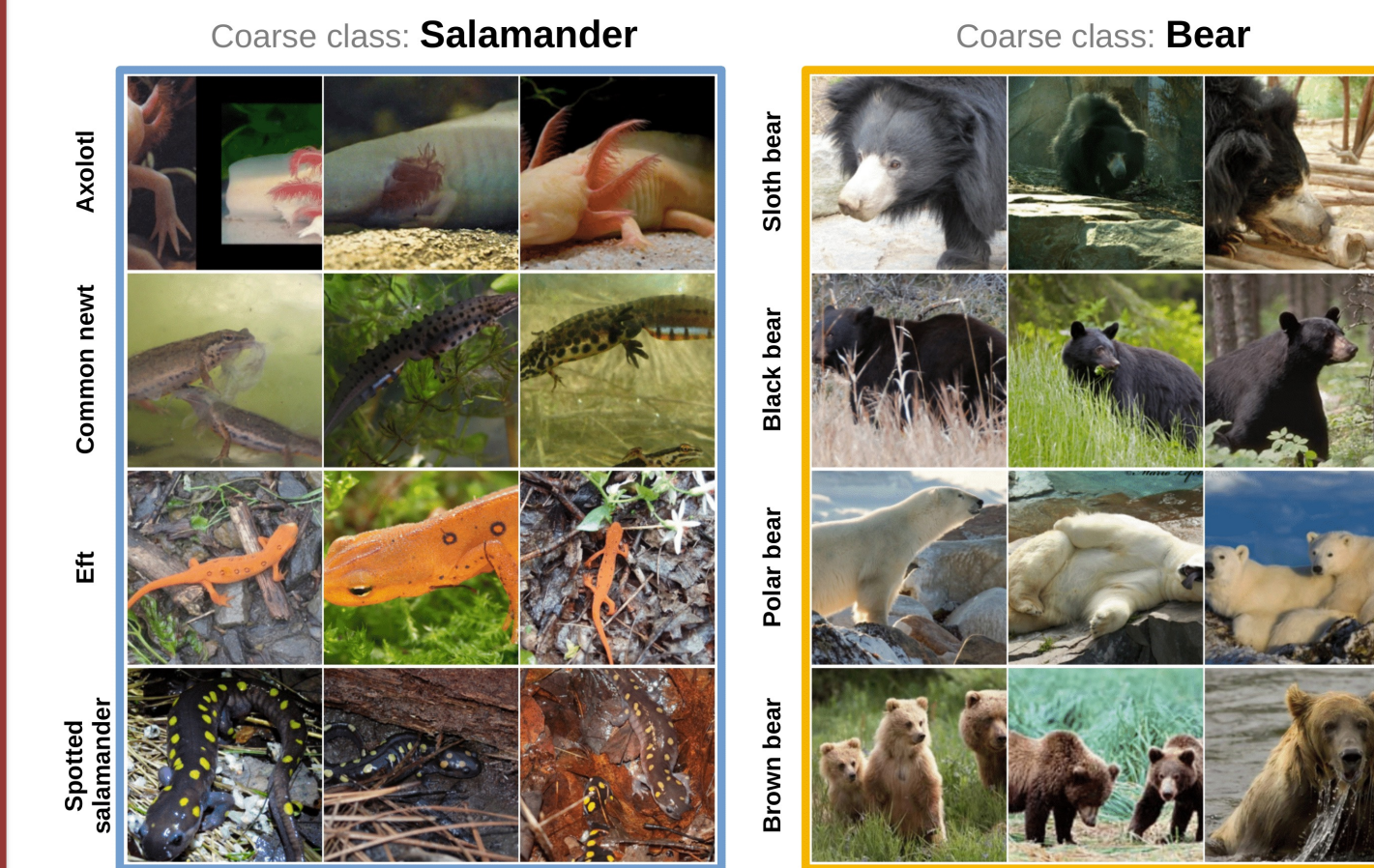
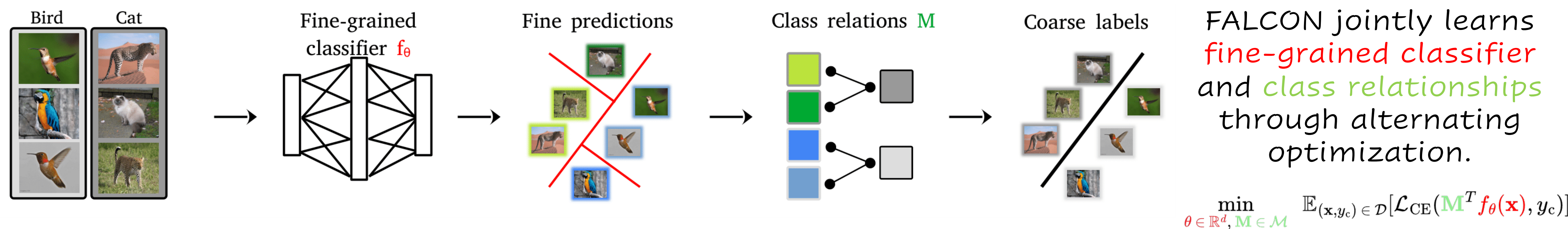**FALCON** discovers fine classes that correspond to subspecies!

FALCON separates classes at finer granularity than provided by the labels.
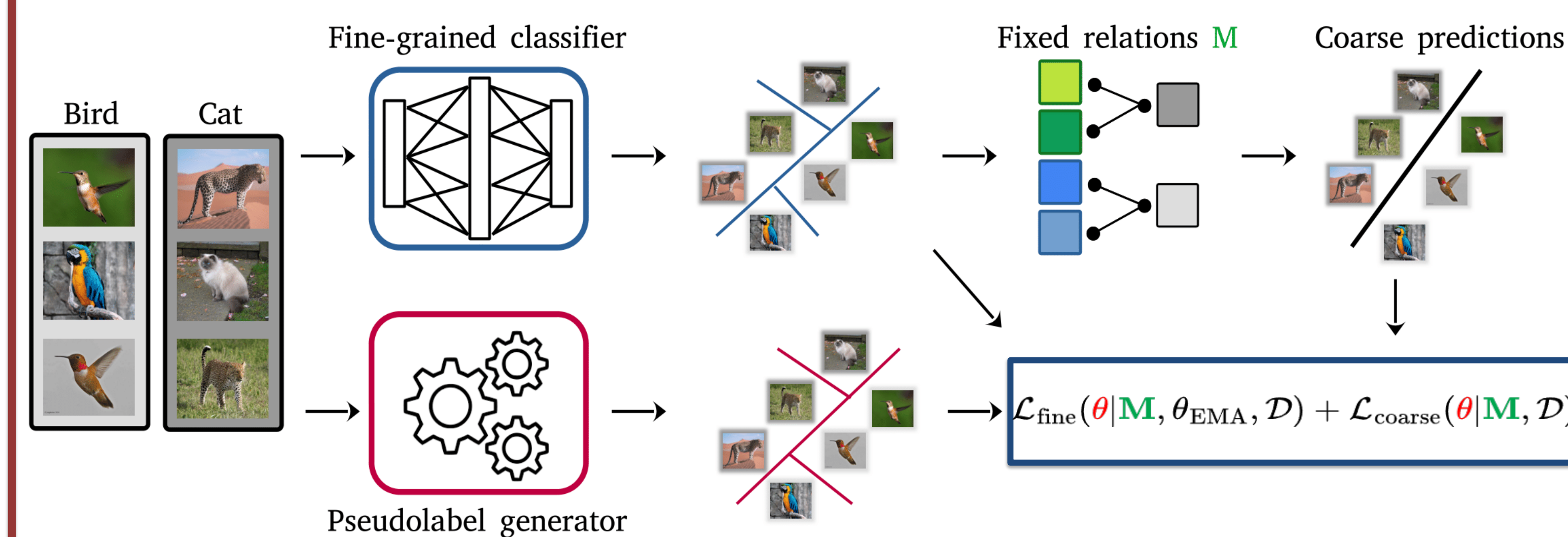
Fine-grained class discovery:
FALCON consistently outperforms all baselines and accurately infers coarse to fine class relations.

Method	Breeds			CIFAR100			tieredImageNet		
	ACC	ARI	GED	ACC	ARI	GED	ACC	ARI	GED
SCGM	57.4	43.4	62.4	47.9	32.2	61.3	46.6	32.0	132.0
SCAN-C	61.5	47.6	–	48.7	36.1	–	48.2	33.2	–
FALCON	**66.6**	**55.3**	**0.0**	**59.6**	**42.5**	**0.0**	**53.4**	**41.6**	**110.7**

FALCON discovers fine-grained classes and infers class relations

Fine-grained classifier f_θ

Fine predictions

Class relations M

Coarse labels

FALCON jointly learns **fine-grained classifier** and **class relationships** through alternating optimization.

$$\min_{\theta \in \mathbb{R}^d, \mathbf{M} \in \mathcal{M}} \mathbb{E}_{(\mathbf{x}, y_c) \in \mathcal{D}} [\mathcal{L}_{CE}(\mathbf{M}^T f_\theta(\mathbf{x}), y_c)]$$

Simultaneous training on multiple datasets

FALCON learns from multiple datasets at once by inferring dataset-specific class relations.

Dataset A — Cat, Bird
Dataset B — Wild animals, Pets

Fine-grained classifier f_θ

Fine predictions

Shared predictions
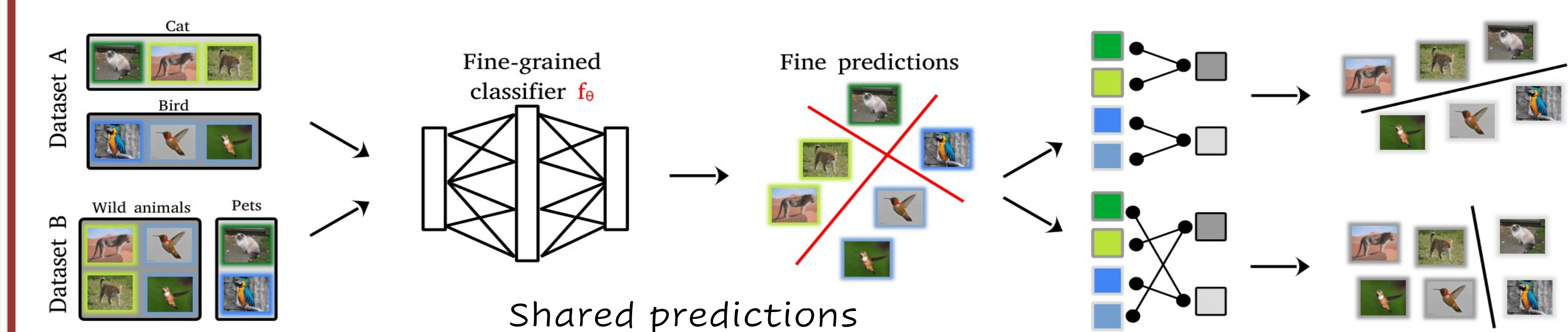
Training on multiple datasets:
FALCON benefits from inconsistent labeling policies.

Dataset	Num Samples	Taxonomy	SCAN-C		FALCON	
			ACC	ARI	ACC	ARI
D_A	N/2	T_A	48.7	35.9	56.0	38.6
D_B	N/2	T_B	47.8	34.4	56.6	38.7
$D_A \cup D_B$	N	T_A & T_B	49.6	36.7	61.5	43.9

Train **fine-grained classifier**, given class relations.

Fine-grained classifier

Fixed relations M

Coarse predictions

Pseudolabel generator

$$\mathcal{L}_{fine}(\theta | \mathbf{M}, \theta_{EMA}, \mathcal{D}) + \mathcal{L}_{coarse}(\theta | \mathbf{M}, \mathcal{D})$$

Coarse level loss:
(i) coarse supervision from the available labels

Fine-level loss:
(i) consistent predictions for neighboring samples
(ii) confident sample assignments to fine-grained classes

Infer **class relations** from fine predictions.

Co-occurrences as edge weights

Input sample
Fine predictions
Coarse label

Class relations are the strongest connections

Regularized bipartite matching problem!