Heterogeneous Graph-based Knowledge Transfer for Generalized Zero-shot Learning

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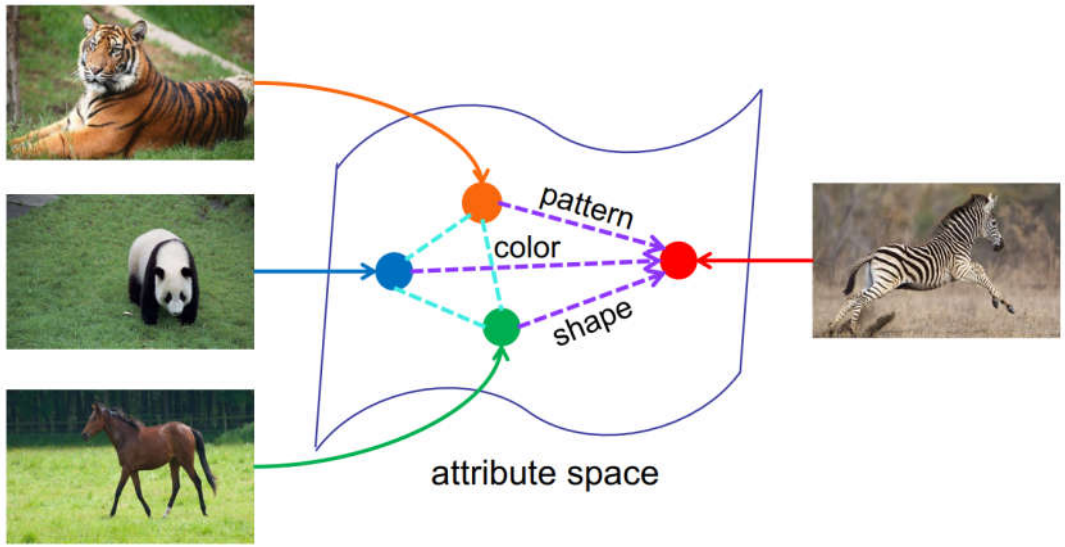
Problem Definition

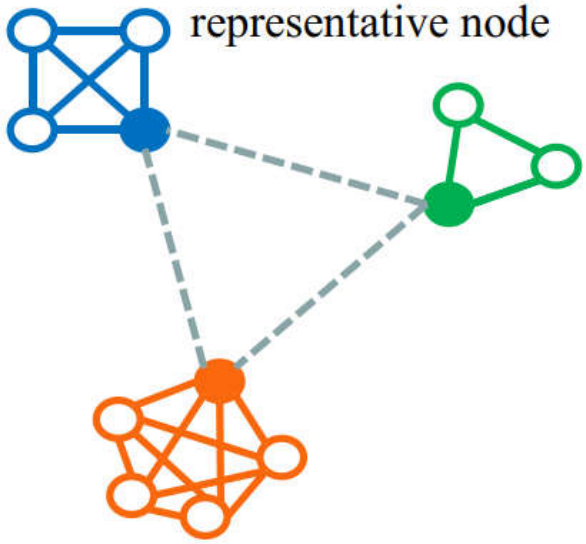
How one can correctly classify those instances from unseen classes which are absent during training?

1	0	0	1	1
Tail	beak	feather	whiskers	furry



How to capture relationship?

Capture inter-class and intra-class relationship jointly by constructing a heterogeneous structured graph.



Intra-class Relationship

- Construct complete graph

Inter-class Relationship

- Compute Wasserstein barycenter

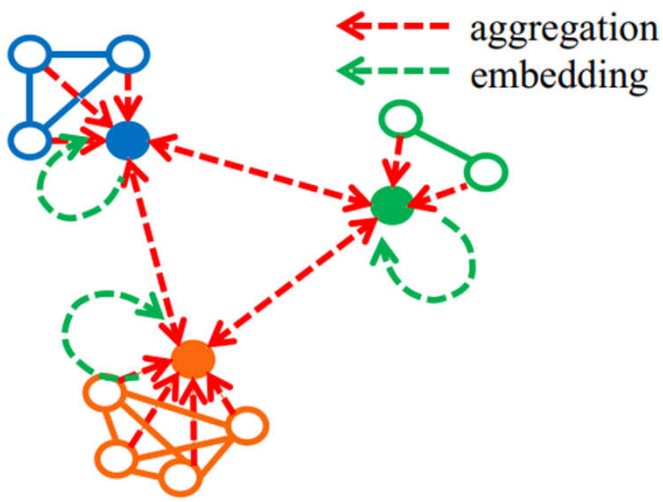
$$\mathcal{WB}(\lambda, \{\mathbf{b}_s\}) = \arg\min_{\mathbf{a}\in\sum_n} \sum_{s=1}^{S} \lambda_s \mathcal{W}_{\mathbf{C}}(\mathbf{a}, \mathbf{b}_s)$$

- Select representative node

$$s_\ell = \arg\min_{x_i} \left\{ \mathcal{L}_C(x_\ell, x_i) \mid y_i = \ell \right\}$$

How to transfer knowledge?

The graph neural network is utilized to transfer knowledge rely on the heterogeneous graph.



Average neighbors' embedding vectors

$$h_{\mathcal{N}(v)} \leftarrow \text{Mean}(\{h_u, \forall u \in \mathcal{N}(v)\}),$$

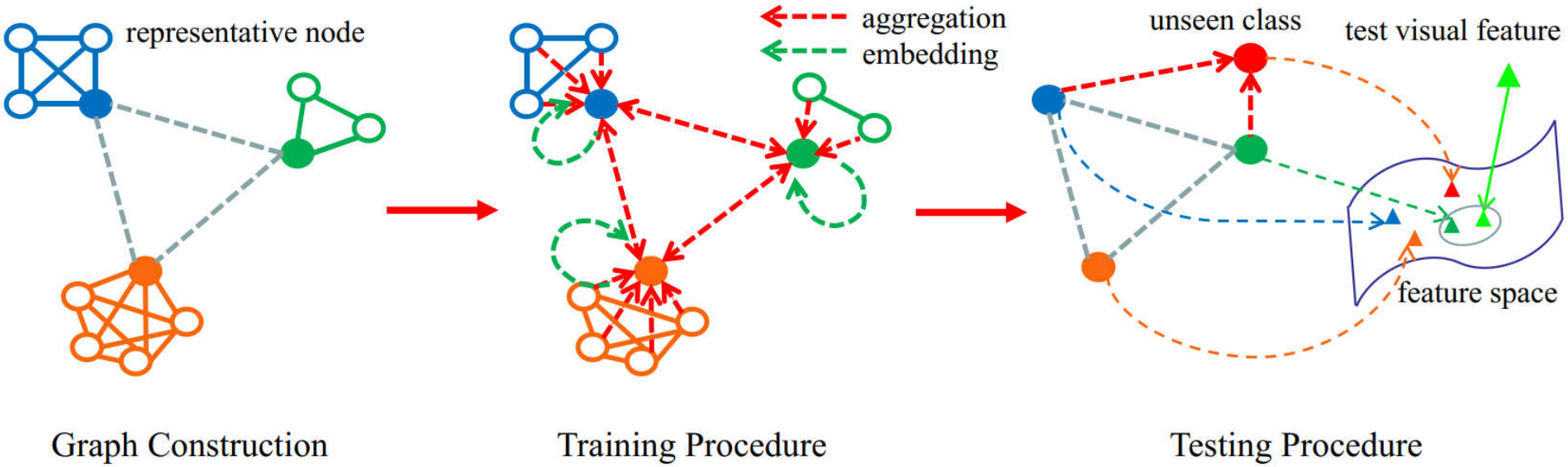
Embed concatenated embedding vectors

$$h_v \leftarrow \delta(W \cdot \text{CONCAT}(h_v, \mu h_{\mathcal{N}(v)}) + b)$$

Minimize the distance

$$\text{loss} := \frac{1}{|D_{tr}|} \sum_{i=1}^{|D_{tr}|} \|h(y_i) - x_i\|^2 + \xi \|W\|^2,$$

Algorithms


representative node
aggregation
embedding
unseen class
test visual feature
feature space
Graph Construction
Training Procedure
Testing Procedure

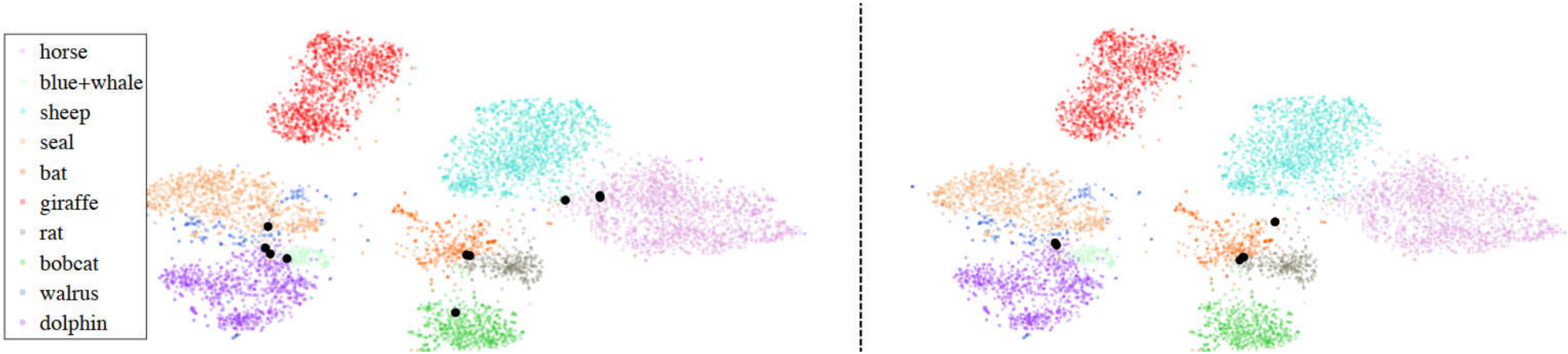
Experiments

Datasets: SUN, CUB, AWA1, AWA2, aPY

Dataset		SUN			CUB			AWA1			AWA2			aPY		
Method	Type	ts	tr	H	ts	tr	H	ts	tr	H	ts	tr	H	ts	tr	H
DAP [11]	Inductive	4.2	25.1	7.2	1.7	67.9	3.3	0.0	**88.7**	0.0	0.0	84.7	0.0	4.8	78.3	9.0
IAP [11]	Inductive	1.0	37.8	1.8	0.2	72.8	0.4	2.1	78.2	4.1	0.9	87.6	1.8	5.7	65.6	10.4
CONSE [29]	Inductive	6.8	39.9	11.6	1.6	72.2	3.1	0.4	88.6	0.8	0.5	**90.6**	1.0	0.0	**91.2**	0.0
CMT [30]	Inductive	8.1	21.8	11.8	7.2	49.8	12.6	0.9	87.6	1.8	0.5	90.0	1.0	1.4	85.2	2.8
CMT* [30]	Inductive	8.7	28.0	13.3	4.7	60.1	8.7	8.4	86.9	15.3	8.7	89.0	15.9	10.9	74.2	19.0
SSE [12]	Inductive	2.1	36.4	4.0	8.5	46.9	14.4	7.0	80.5	12.9	8.1	82.5	14.8	0.2	78.9	0.4
LATEM [31]	Inductive	14.7	28.8	19.5	15.2	57.3	24.0	7.3	71.7	13.3	11.5	77.3	20.0	0.1	73.0	0.2
ALE [32]	Inductive	21.8	33.1	26.3	23.7	62.8	34.4	16.8	76.1	27.5	14.0	81.8	23.9	4.6	73.7	8.7
DEVISE [18]	Inductive	16.9	27.4	20.9	23.8	53.0	32.8	13.4	68.7	22.4	17.1	74.7	27.8	4.9	76.9	9.2
SJE [33]	Inductive	14.7	30.5	19.8	23.5	59.2	33.6	11.3	74.6	19.6	8.0	73.9	14.4	3.7	55.7	6.9
ESZSL [13]	Inductive	11.0	27.9	15.8	12.6	63.8	21.0	6.6	75.6	12.1	5.9	77.8	11.0	2.4	70.1	4.6
SYNC [34]	Inductive	7.9	**43.4**	13.4	11.5	**70.9**	19.8	8.9	87.3	16.2	10.0	90.5	18.0	7.4	66.3	13.3
SAE [35]	Inductive	8.8	18.0	11.8	7.8	54.0	13.6	1.8	77.1	3.5	1.1	82.2	2.2	0.4	80.9	0.9
GFZSL [36]	Inductive	0.0	39.6	0.0	0.0	45.7	0.0	1.8	80.3	3.5	2.5	80.1	4.8	0.0	83.3	0.0
DEM [15]	Inductive	20.5	34.3	25.6	19.6	57.9	29.2	32.8	84.7	47.3	30.5	86.4	45.1	11.1	75.1	19.4
PSRZSL [19]	Inductive	20.8	37.2	26.7	24.6	54.3	33.9	-	-	-	20.7	73.8	32.3	13.5	51.4	21.4
GAFE [21]	Inductive	19.6	31.9	24.3	22.5	52.1	31.4	25.5	76.6	38.2	26.8	78.3	40.0	15.8	68.1	25.7
HGKT (Ours)	Inductive	**22.3**	36.5	**27.7**	**25.2**	56.9	**34.9**	**39.4**	83.5	**53.6**	**37.9**	86.5	**52.7**	**18.3**	79.0	**29.7**

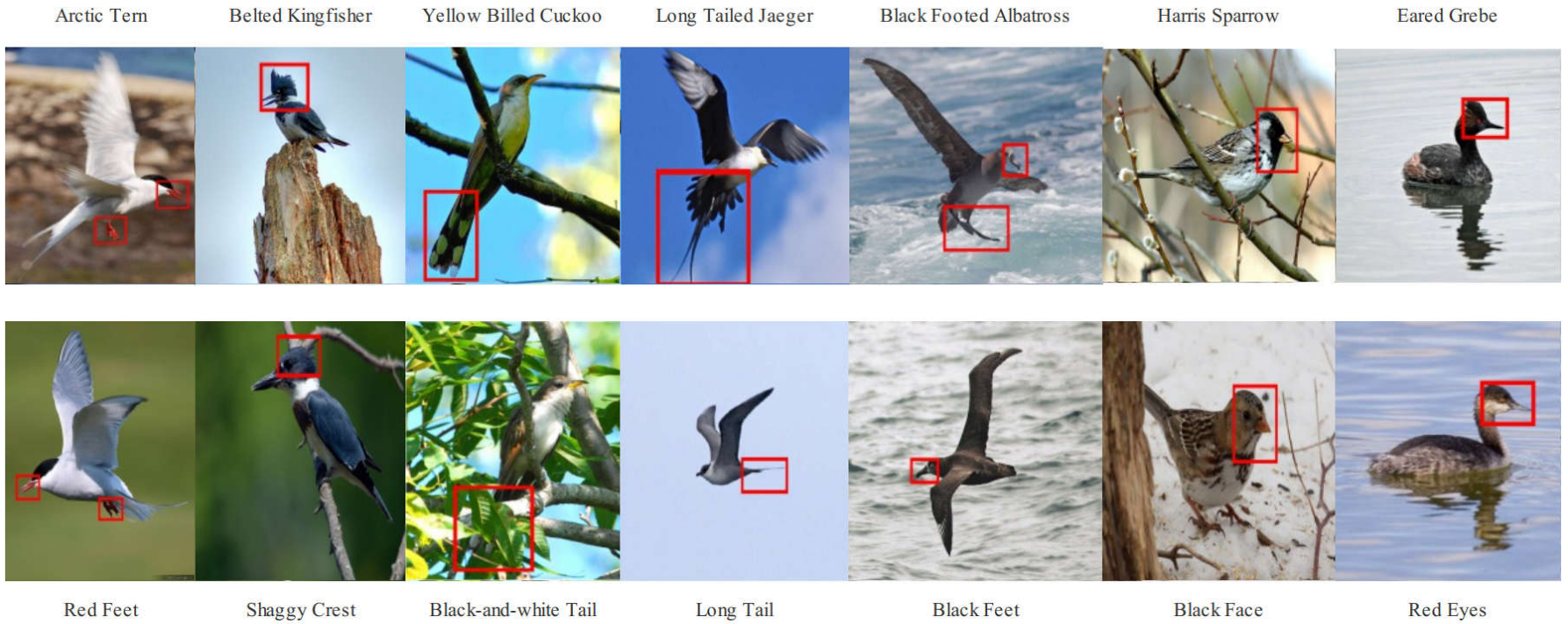
Experiments

T-SNE visualization of the ten unseen classes on AWA2.



Experiments

Representative images selected by Wasserstein measure and Euclidean measure on CUB dataset.



Thank you for watching!