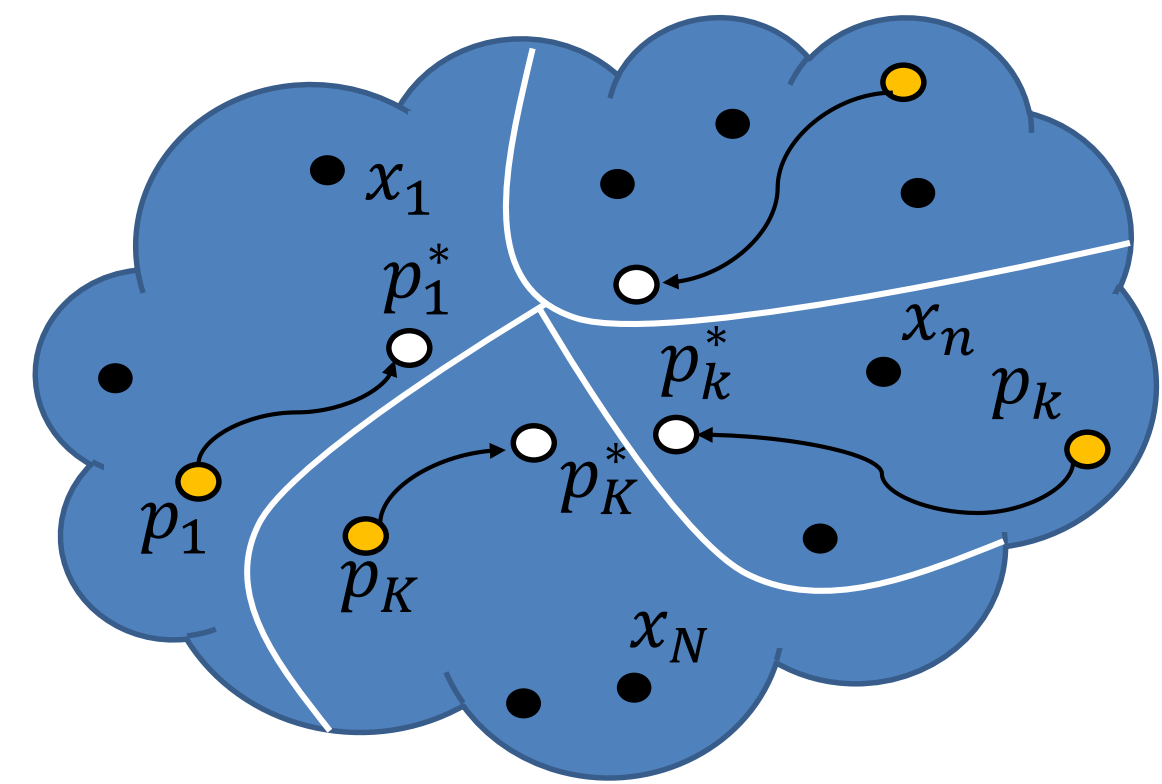


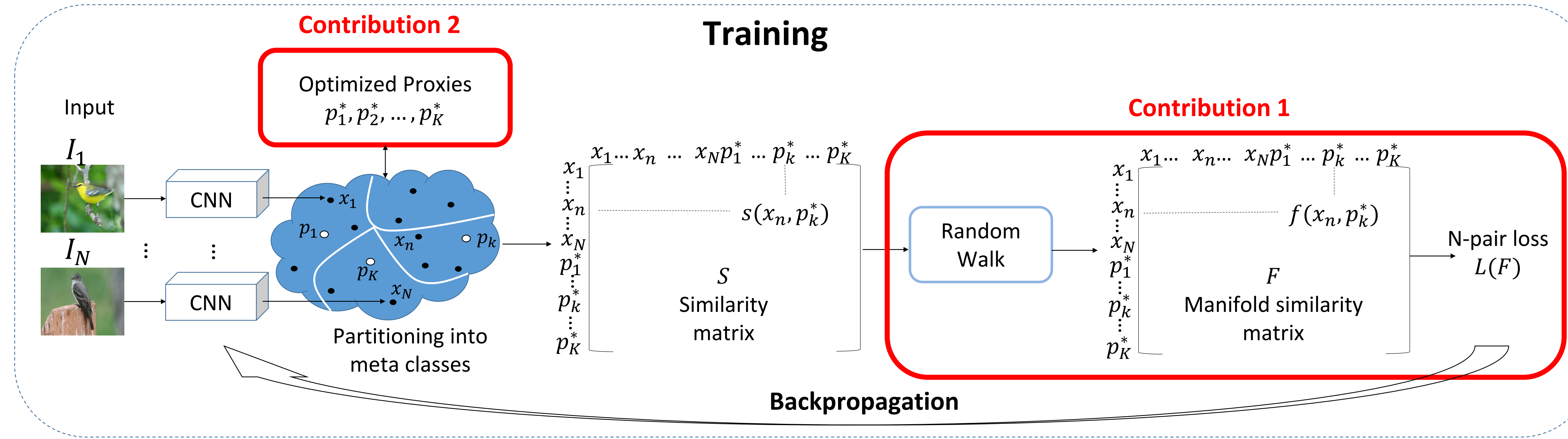
Problem: Learn a deep image representation for retrieval and clustering

Contributions:

1. Partition the manifold into meta-classes and represent them by proxies made similar to one another – hard proxies



2. Manifold image similarity efficiently computed using the closed-form Random Walk



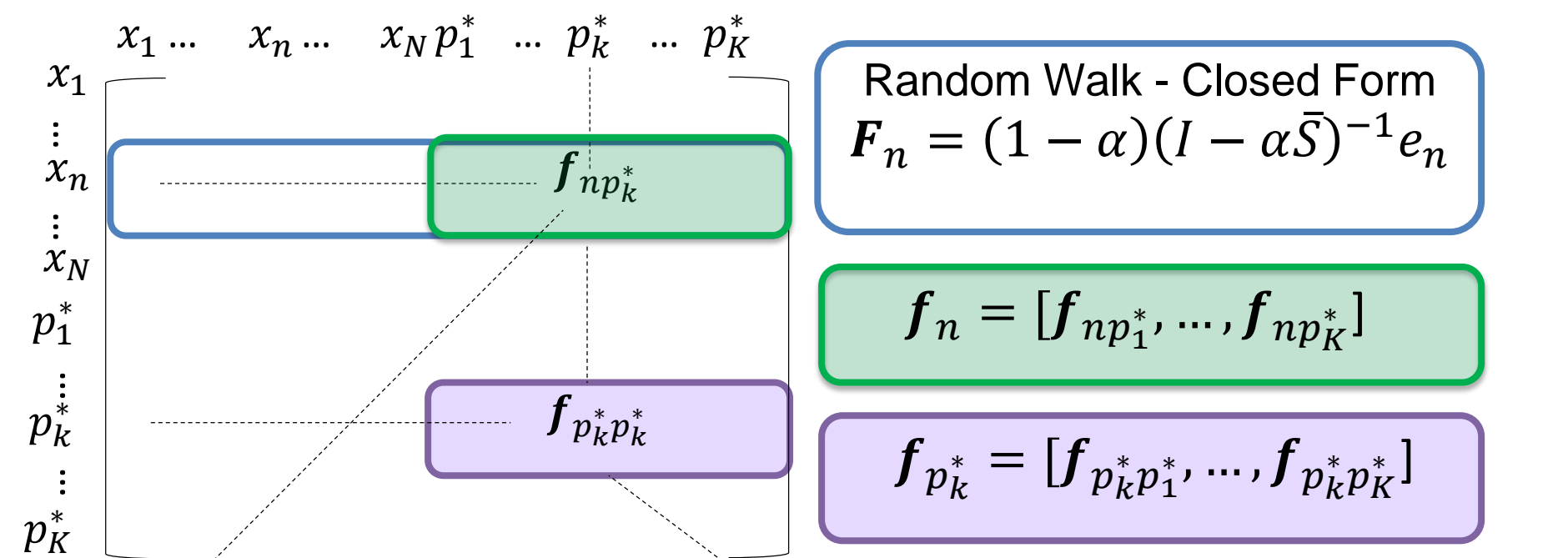
Many-to-many N-pair Loss

$$L(\{x_n\}_1^N) = \frac{1}{N} \sum_{n=1}^N \log \left(1 + \sum_{\substack{j=1 \\ j \neq k}}^K e^{(s(f_n, f_{p_j^*}) - s(f_n, f_{p_k^*}) + m)} \right)$$

Image Clustering and Retrieval

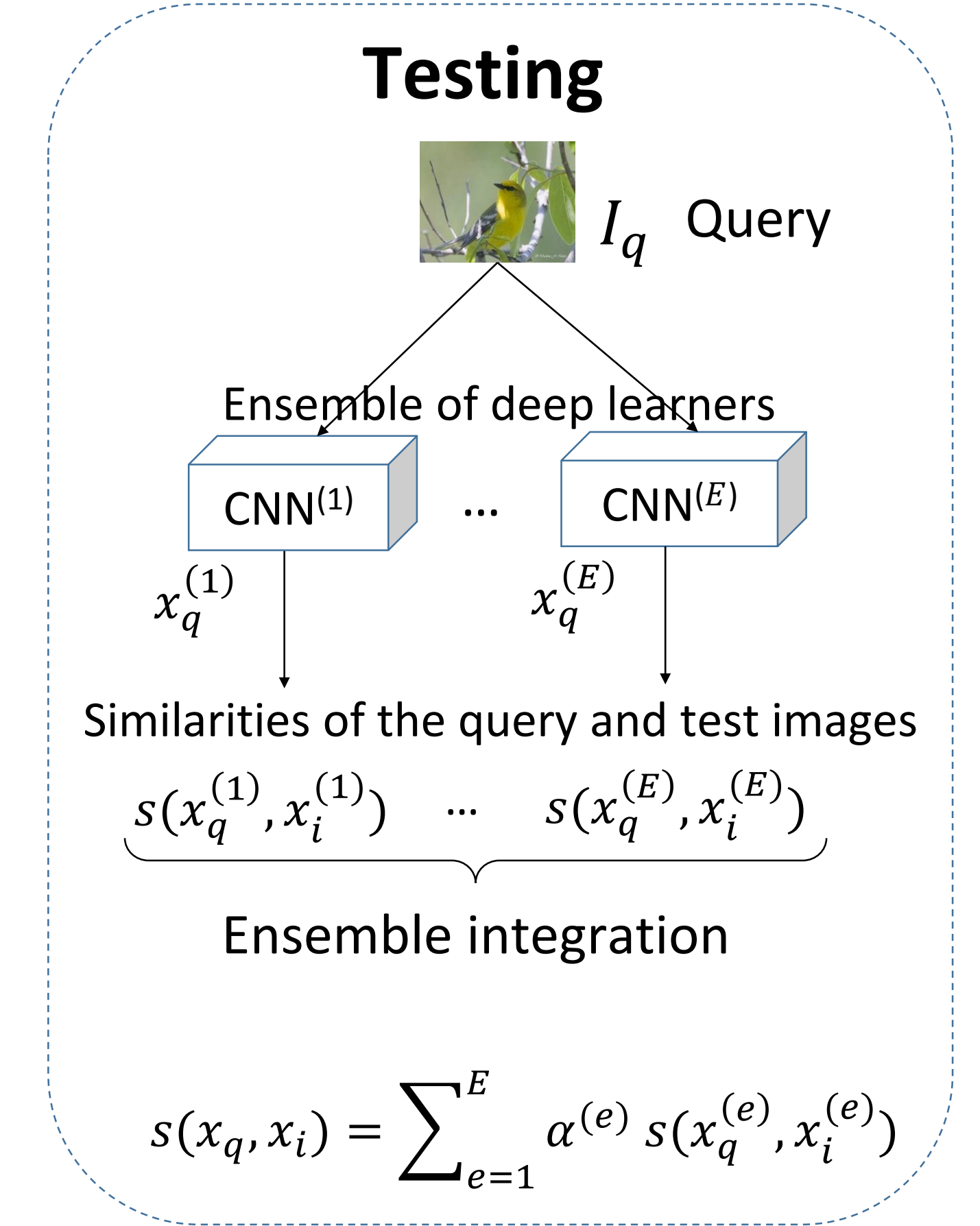
Dataset	Method	Network	CUB-200-2011					Car196				
			NMI	R@1	R@2	R@4	R@8	NMI	R@1	R@2	R@4	R@8
Lifted [Song CVPR '16]		GoogLeNet	55.38	47.2	58.9	70.2	80.2	55.1	48.3	61.1	71.8	81.1
Proxy-NCA [Movshovitz CVPR '17]		InceptionBN	59.5	49.2	61.9	67.9	72.4	64.9	73.2	82.4	86.4	88.7
N-pair [Sohn NIPS 2016]		GoogLeNet	60.4	51	63.3	74.3	83.2	64	71.1	79.7	86.5	91.6
Angular [Wang ICCV 2017]		GoogLeNet	61.1	54.7	66.3	76	83.9	63.2	71.4	81.4	87.5	92.1
BIER [Opitz ICCV 2017]		GoogLeNet	-	55.3	68.4	76.9	85.1	-	78	85.8	91.1	95.1
ABE [Kim ECCV 2018]		GoogLeNet	-	60.6	71.5	79.8	87.7	-	85.2	90.5	94	96.1
DREML [Xuan ECCV 2018]		ResNet18	67.8	63.9	75	83.1	89.7	76.4	86	91.7	95	97
Our approach EDMS		GoogLeNet	64.5	61.6	72.1	81.8	88.9	75.1	85.6	90.8	94.8	96.1
Our approach EDMS		ResNet18	68.9	66.1	76.7	85.5	91.4	76.7	87.6	92.1	95.2	97.3

Manifold Similarity Matrix



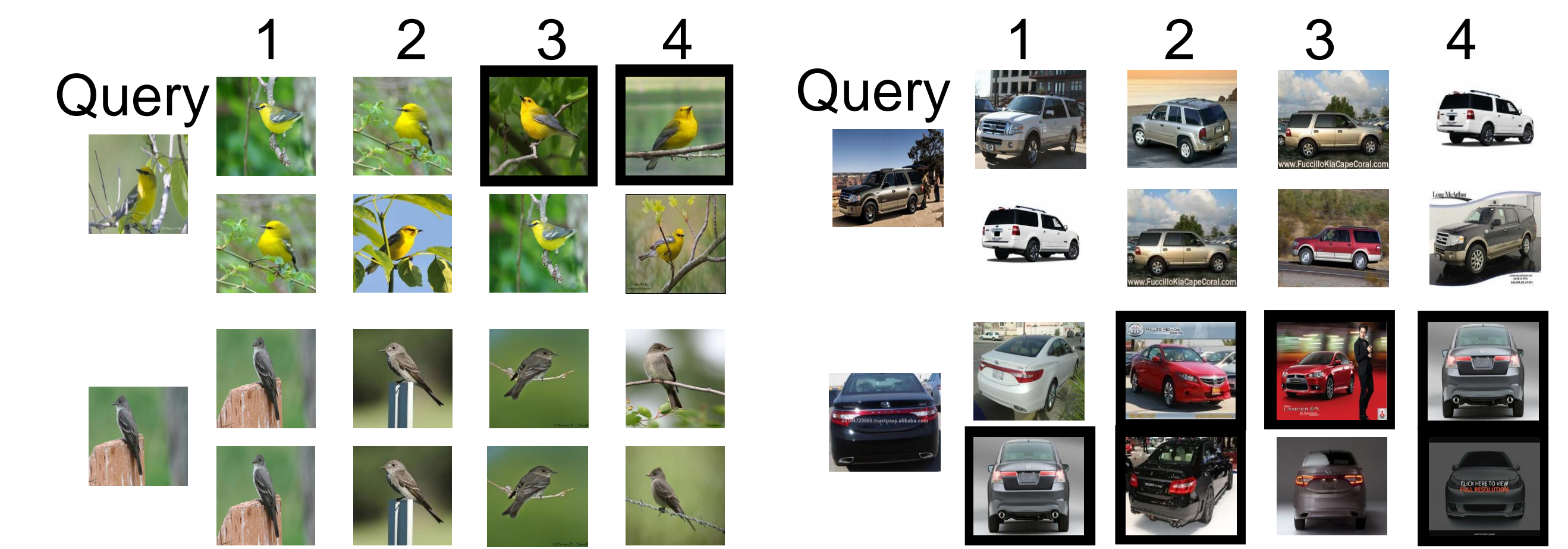
manifold similarity between image n and hard proxie p_k^*

manifold similarity between two hard proxies p_k^* and p_k^*



Two Rows of Retrieval Results for a Query

Top Row: Euclidean similarity; Bottom Row: Manifold Similarity
Errors highlighted with the black frame.



Acknowledgment: DARPA XAI Award N66001-17-2-4029