Boosting Few-Shot Learning with Adaptive Margin Loss

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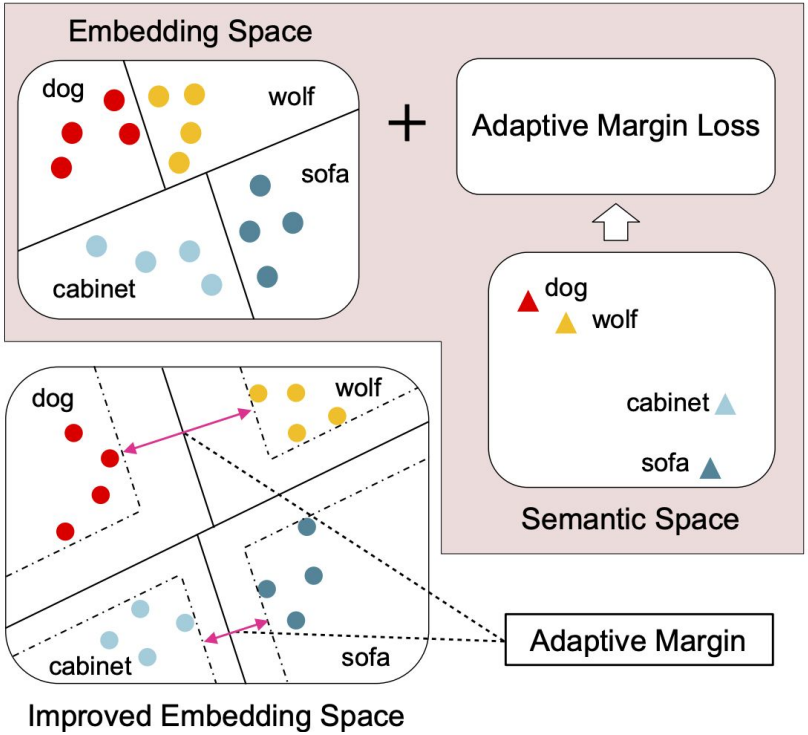
Intuition

Propose an adaptive margin principle to improve the generalization ability of metric-based meta-learning

Arguments:

Semantic similarity between different classes should be larger than the one between dissimilar classes



Naive Additive Margin Loss (NAML)

Increase the distances between classes

$$\mathcal{L}^{\mathrm{na}} = -\frac{1}{|Q|} \sum_{(x,y)\in Q} \log p^{\mathrm{na}}(y|x,S),$$

$$p^{\mathrm{na}}(y|x,S) = \frac{e^{\mathcal{D}(\mathcal{F}(x),r_y)}}{e^{\mathcal{D}(\mathcal{F}(x),r_y)} + \sum_{k\in C_t\setminus\{y\}} e^{\mathcal{D}(\mathcal{F}(x),r_k)+m}}.$$

Where: S, Q are support set and query set

F is an encoder function, r is class representation embedding

Class-Relevant Additive Margin Loss (CRAML)

Semantic similarity based on class name

$$m_{i,j}^{\mathrm{cr}} := \mathcal{M}(e_i, e_j) = \alpha \cdot \mathrm{sim}(e_i, e_j) + \beta,$$

Class-relevant additive margin loss

$$p^{\mathrm{cr}}(y|x,S) = \frac{e^{\mathcal{D}(\mathcal{F}(x), r_y)}}{e^{\mathcal{D}(\mathcal{F}(x), r_y)} + \sum_{k \in C_t \setminus \{y\}} e^{\mathcal{D}(\mathcal{F}(x), r_k)) + m_{y,k}^{\mathrm{cr}}}}$$

Task-Relevant Additive Margin Loss (TRAML)

$$\{m^{\mathrm{tr}}_{y,k}\}_{k\in C_t\setminus\{y\}} = \mathcal{G}\left(\{\mathrm{sim}(e_y, e_k)\}_{k\in C_t\setminus\{y\}}\right),$$

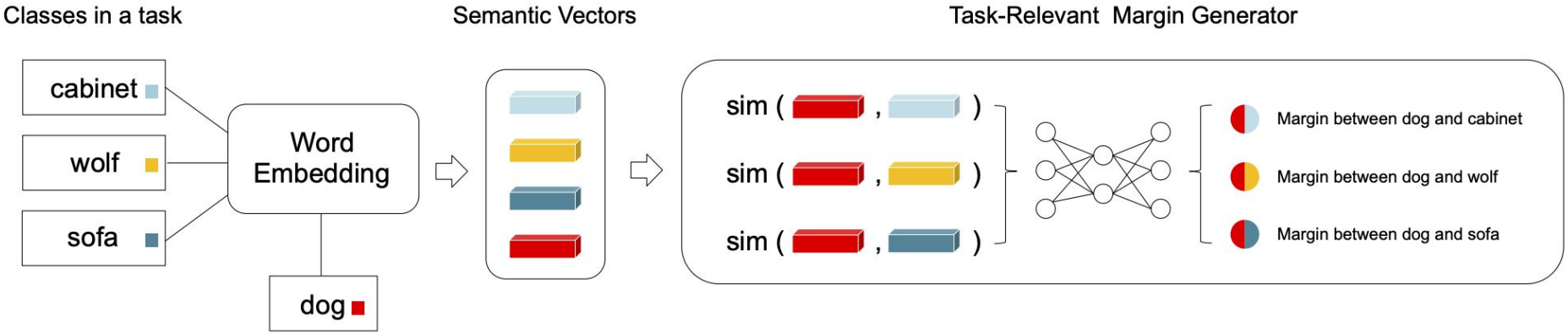


Figure 3. The illustration of the architecture of our task-relevant margin generator.

Result on miniImageNet

Model	Backbone	Type	Test Accuracy	
			5-way 1-shot	5-way 5-shot
Matching Networks [31]	4Conv	Metric	43.56 ± 0.84	55.31 ± 0.73
Prototypical Network [27]	4Conv	Metric	49.42 ± 0.78	68.20 ± 0.66
Relation Networks [27]	4Conv	Metric	50.44 ± 0.82	65.32 ± 0.70
GCR [15]	4Conv	Metric	53.21 ± 0.40	72.34 ± 0.32
Memory Matching Network [3]	4Conv	Metric	53.37 ± 0.48	66.97 ± 0.35
Dynamic FSL [8]	4Conv	Metric	56.20 ± 0.86	73.00 ± 0.64
Prototypical Network [27]	ResNet12	Metric	56.52 ± 0.45	74.28 ± 0.20
TADAM [20]	ResNet12	Metric	58.50 ± 0.30	76.70 ± 0.38
DC [17]	ResNet12	Metric	62.53 ± 0.19	78.95 ± 0.13
TapNet [36]	ResNet12	Metric	61.65 ± 0.15	76.36 ± 0.10
ECMSFMT [24]	ResNet12	Metric	59.00	77.46
AM3 (Prototypical Network) [35]	ResNet12	Metric	65.21±0.49	75.20 ± 0.36
MAML [7]	4Conv	Gradient	48.70 ± 1.84	63.11 ± 0.92
MAML++ [1]	4Conv	Gradient	52.15 ± 0.26	68.32 ± 0.44
iMAML [22]	4Conv	Gradient	49.30 ± 1.88	-
LCC [19]	4Conv	Gradient	54.6 ± 0.4	71.1 ± 0.4
CAML [11]	ResNet12	Gradient	59.23 ± 0.99	72.35 ± 0.18
MTL [28]	ResNet12	Gradient	61.20 ± 1.80	75.50 ± 0.80
MetaOptNet-SVM [12]	ResNet12	Gradient	62.64 ± 0.61	78.63 ± 0.46
Prototypical Network + TRAML (OURS)	ResNet12	Metric	60.31 ± 0.48	77.94 ± 0.57
AM3 (Prototypical Network) + TRAML (OURS)	ResNet12	Metric	**67.10** ± 0.52	**79.54** ± 0.60

Ablation Study on miniImagenet

Model	Test Accuracy	
	5-way 1-shot	5-way 5-shot
Original Classification Loss	65.21 ± 0.49	75.20 ± 0.36
Naive Additive Margin Loss	65.42 ± 0.25	75.48 ± 0.34
Class-Relevant Additive Margin Loss	66.36 ± 0.57	77.21 ± 0.48
Our Full Model	$\mathbf{67.10} \pm 0.52$	$\mathbf{79.54} \pm 0.60$