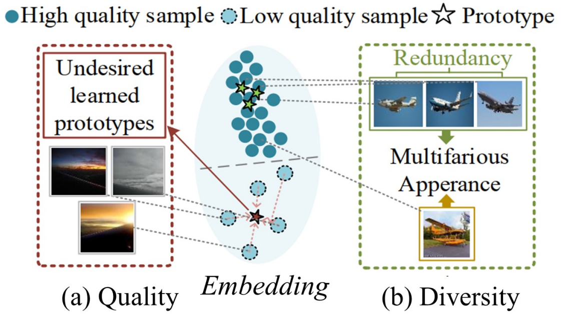
PMAL: Open Set Recognition via Robust Prototype Mining

Jing Lu[1]*, Yunlu Xu[1]*, Hao Li[1], Zhanzhan Cheng[1,2]†, Yi Niu[1]

[1] Hikvision Research Institution, Hangzhou, China
[2] Zhejiang University, Hangzhou, China
{lujing6, xuyunlu, lihao50, chengzhanzhan, niuyi}@hikvision.com

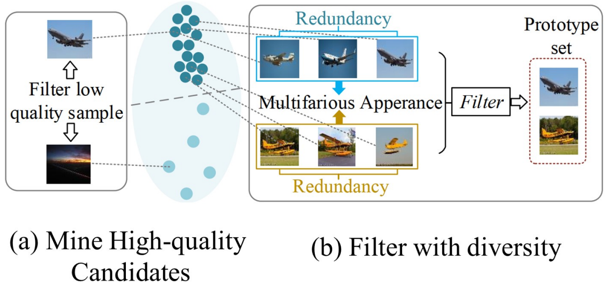
Problem

- *Implicitly* Learned Prototypes



Idea

- *Explicit* Prototype Mining

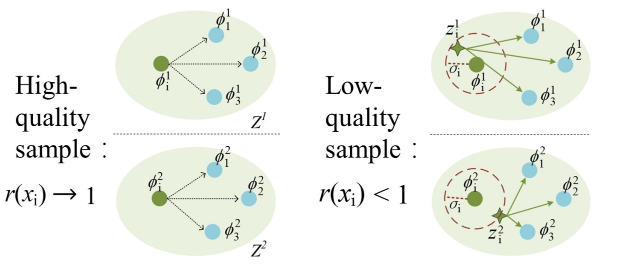


Contribution

- Instead of implicitly learn prototypes, we mine prototypes with two explicit criterias for OSR task, namely the *high-quality* and *diversity*.
- We propose a framework by prototype mining and learning orderly. In prototype mining, two key attributes are considered. In prototype learning, with the chosen prototypes as fixed anchors, a better embedding space is learned.
- PMAL shows more stable and superior performance especially in complicated large-scale tasks.

Method

- *High-quality Candidate Selection*

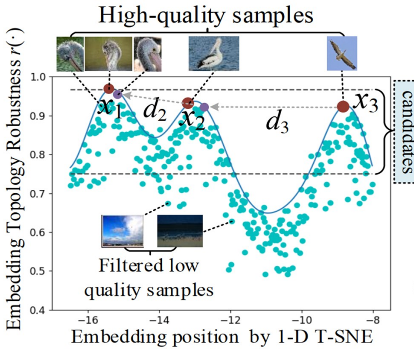


✓ Embedding Topology Robustness :

$$r(x_i) \triangleq exp(-||t(z_i^1) - t(z_i^2)||_2)$$

$$t(z_i) \triangleq (d_{\mathcal{M}}(z_i, z_1), ..., d_{\mathcal{M}}(z_i, z_N))$$

- *Diverse Prototype-Set Filtering*

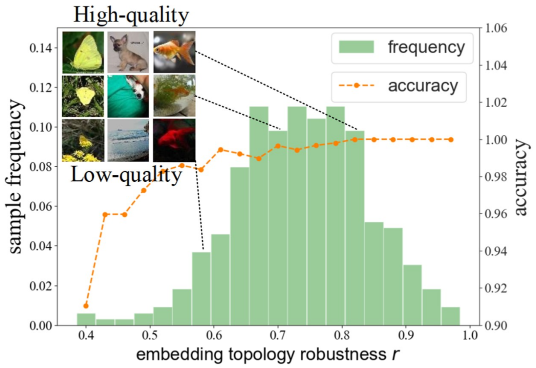


✓ Local maximum robustness

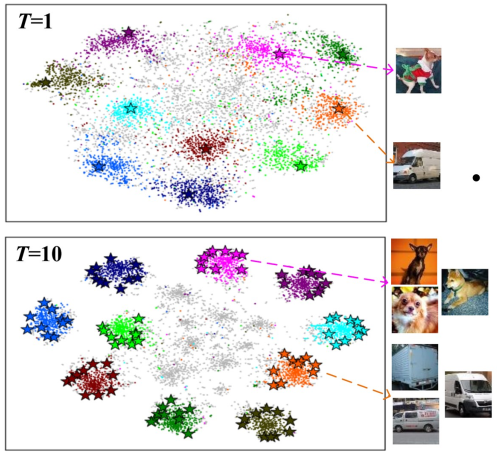
✓ Large embedding distance

(x^1, x^2, x^3)

Ablation



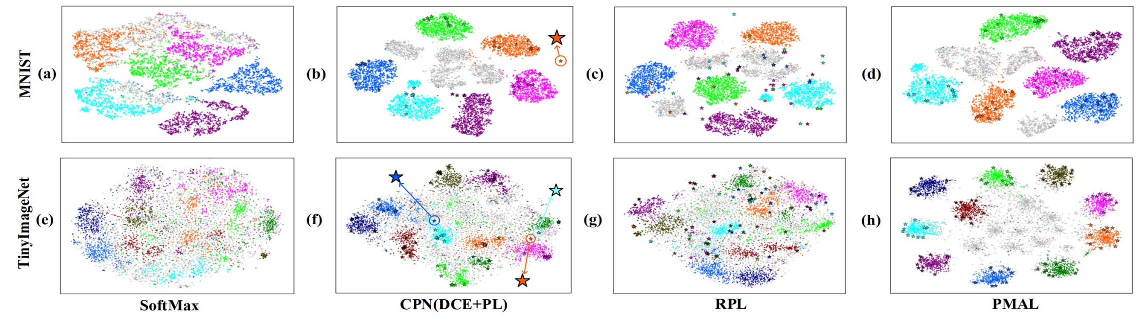
- High-quality candidates



- Diverse prototot-ype Set

Visualization

- Embedding space of different approaches (Zoom in)



Performance

('C'/'IN' is short for 'CIFAR'/'ImageNet')

Methods	Close set ACC						Open set AUROC					
	MNIST	SVHN	C10	C+10	C+50	TINY	MNIST	SVHN	C10	C+10	C+50	TINY
SoftMax	99.5	94.7	80.1	-	-	-	97.8	88.6	67.7	81.6	80.5	57.7
CPN (Yang et al.)	99.7	96.7	92.9	94.8*	95.0*	81.4*	99.0	92.6	82.8	88.1	87.9	63.9
PROSER (Zhou, Ye, and Zhan)	-	96.5	92.8	-	-	52.1	94.3	-	89.1	96.0	95.3	69.3
CGDL (Sun et al.)	99.6	94.2	91.2	-	-	-	99.4	93.5	90.3	95.9	95.0	76.2
OpenHybrid (Zhang et al.)	94.7	92.9	86.8	-	-	-	99.5	94.7	95.0	96.2	95.5	79.3
RPL-OSCRI (Chen et al.)	99.5*	95.3*	94.3*	94.6*	94.7*	81.3*	99.3	95.1	86.1	85.6	85.0	70.2
ARPL (Chen et al.)	99.5	94.3	87.9	94.7	92.9	65.9	99.7	96.7	91.0	97.1	95.1	78.2
RPL-WRN (Chen et al.)	99.6*	95.8*	95.1*	95.5*	95.9*	81.7*	99.6	96.8	90.1	97.6	96.8	80.9
PMAL-OSCRI	99.6	96.5	96.3	96.4	96.9	84.4	99.5	96.3	94.6	96.0	94.3	81.8
PMAL-WRN	**99.8**	**97.1**	**97.5**	**97.8**	**98.1**	**84.7**	**99.7**	**97.0**	**95.1**	**97.8**	**96.9**	**83.1**

- Comparisons on mainstream small benchmarks

Method	Close Set ACC			Open Set AUROC			Additional Params		
	IN-LT	IN-100	IN-200	IN-LT	IN-100	IN-200	IN-LT	IN-100	IN-200
Softmax	37.8	81.7	79.7	53.3	79.7	78.4	0	0	0
CPN	37.1	86.1	82.1	54.5	82.3	79.5	2M	0.2M	0.4M
RPL	39.0	81.8*	80.7*	55.1	81.2*	80.2*	2M	0.2M	0.4M
RPL++	39.7	-	-	55.2	-	-	4M	-	-
PMAL	**42.9**	**86.2**	**84.1**	**71.7**	**94.9**	**93.9**	0	0	0

- Comparisons on complex large benchmarks