

FA: Forced Prompt Learning of Vision-Language Models for Out-of-Distribution Detection

Appendix / Supplementary Material

A. More experimental details of OOD detection with ImageNet-1k.

Referring to Section 5.2, we also conduct experiments under other few-shot settings on both conventional and challenging ImageNet-1k OOD benchmarks. As shown in Tab. 8 and Tab. 9, our FA achieves superior average performance.

Method	iNaturalist		SUN		Places		Textures		Average	
	FPR95↓	AUROC↑	FPR95↓	AUROC↑	FPR95↓	AUROC↑	FPR95↓	AUROC↑	FPR95↓	AUROC↑
CoOp _{MCM}	33.73 $\pm$ 5.73	92.79 $\pm$ 1.28	37.15 $\pm$ 1.52	92.17 $\pm$ 0.26	44.58 $\pm$ 1.43	89.57 $\pm$ 0.32	47.27 $\pm$ 0.64	89.25 $\pm$ 0.57	36.17 $\pm$ 1.43	92.18 $\pm$ 0.34
CoOp _{GL}	18.92 $\pm$ 3.46	95.36 $\pm$ 0.94	29.59 $\pm$ 1.89	92.67 $\pm$ 0.76	37.55 $\pm$ 1.19	90.11 $\pm$ 0.35	51.35 $\pm$ 2.19	84.99 $\pm$ 1.50	34.35 $\pm$ 1.87	90.78 $\pm$ 0.78
LoCoOp _{MCM}	29.60 $\pm$ 5.72	93.86 $\pm$ 1.19	32.05 $\pm$ 1.88	93.62 $\pm$ 0.29	40.63 $\pm$ 1.54	90.59 $\pm$ 0.28	42.41 $\pm$ 1.72	90.66 $\pm$ 0.30	36.17 $\pm$ 1.43	92.18 $\pm$ 0.33
LoCoOp _{GL}	19.30 $\pm$ 3.01	95.98 $\pm$ 0.67	23.32 $\pm$ 1.87	95.05 $\pm$ 0.53	33.25 $\pm$ 1.77	91.75 $\pm$ 0.35	44.10 $\pm$ 2.52	89.25 $\pm$ 0.38	29.99 $\pm$ 1.49	93.01 $\pm$ 0.38
IDLike	23.93 $\pm$ 4.26	94.92 $\pm$ 1.77	52.70 $\pm$ 8.49	88.71 $\pm$ 2.67	52.49 $\pm$ 9.67	88.49 $\pm$ 3.11	<u>28.31</u> $\pm$ 3.52	<u>93.93</u> $\pm$ 0.64	39.35 $\pm$ 2.60	91.51 $\pm$ 1.32
SCT _{MCM}	34.91 $\pm$ 4.20	92.90 $\pm$ 0.73	31.84 $\pm$ 3.72	93.29 $\pm$ 0.79	38.89 $\pm$ 2.97	90.49 $\pm$ 0.56	42.70 $\pm$ 4.13	90.36 $\pm$ 0.61	37.08 $\pm$ 2.95	91.76 $\pm$ 0.48
SCT _{GL}	<u>18.46</u> $\pm$ 1.71	<u>96.06</u> $\pm$ 0.13	<u>27.22</u> $\pm$ 5.49	93.57 $\pm$ 1.70	<u>32.46</u> $\pm$ 1.26	91.39 $\pm$ 0.30	43.59 $\pm$ 2.84	88.61 $\pm$ 0.51	<u>30.43</u> $\pm$ 0.85	92.41 $\pm$ 0.41
FA _{MCM} (Ours)	26.91 $\pm$ 3.49	94.47 $\pm$ 0.64	35.98 $\pm$ 2.71	92.65 $\pm$ 0.61	33.69 $\pm$ 0.51	92.78 $\pm$ 0.07	25.61 $\pm$ 1.95	94.59 $\pm$ 0.19	30.55 $\pm$ 0.83	<u>93.63</u> $\pm$ 0.24
FA _{GL} (Ours)	14.01 $\pm$ 1.62	96.75 $\pm$ 0.37	29.10 $\pm$ 2.32	93.26 $\pm$ 0.57	30.77 $\pm$ 0.45	<u>92.59</u> $\pm$ 0.19	30.98 $\pm$ 2.47	92.48 $\pm$ 0.64	26.21 $\pm$ 1.09	93.77 $\pm$ 0.24

Table 8. Conventional ImageNet-1k OOD benchmark under the 4-shot setting. We use the same notation as Tab. 1

Method	OpenImage-O		NINCO		ImageNet-O		Average	
	FPR95↓	AUROC↑	FPR95↓	AUROC↑	FPR95↓	AUROC↑	FPR95↓	AUROC↑
1-shot								
CoOp _{MCM}	43.67 $\pm$ 5.22	90.91 $\pm$ 1.01	80.32 $\pm$ 1.69	71.28 $\pm$ 1.46	73.08 $\pm$ 2.22	79.13 $\pm$ 0.81	65.69 $\pm$ 2.74	80.44 $\pm$ 0.94
CoOp _{GL}	37.36 $\pm$ 3.79	91.03 $\pm$ 0.88	74.38 $\pm$ 1.13	73.55 $\pm$ 1.79	71.27 $\pm$ 1.66	76.16 $\pm$ 1.41	61.01 $\pm$ 2.03	80.25 $\pm$ 1.23
LoCoOp _{MCM}	44.57 $\pm$ 1.58	90.52 $\pm$ 0.44	81.19 $\pm$ 1.64	70.18 $\pm$ 1.96	75.60 $\pm$ 1.96	78.87 $\pm$ 0.92	67.12 $\pm$ 1.65	79.86 $\pm$ 0.99
LoCoOp _{GL}	38.46 $\pm$ 1.54	91.15 $\pm$ 0.25	76.95 $\pm$ 0.25	70.62 $\pm$ 1.63	72.26 $\pm$ 1.23	78.80 $\pm$ 0.91	62.56 $\pm$ 1.63	80.19 $\pm$ 0.82
IDLike	47.48 $\pm$ 7.36	89.54 $\pm$ 2.00	71.61 $\pm$ 5.34	76.02 $\pm$ 2.66	79.45 $\pm$ 4.03	71.59 $\pm$ 0.86	66.18 $\pm$ 5.58	79.05 $\pm$ 1.84
SCT _{MCM}	43.32 $\pm$ 7.06	91.04 $\pm$ 1.47	81.23 $\pm$ 1.78	67.81 $\pm$ 1.78	75.01 $\pm$ 2.24	<u>80.57</u> $\pm$ 1.03	66.52 $\pm$ 3.53	79.81 $\pm$ 1.05
SCT _{GL}	<u>35.21</u> $\pm$ 5.99	<u>91.93</u> $\pm$ 1.43	75.37 $\pm$ 2.52	70.33 $\pm$ 1.19	70.57 $\pm$ 3.00	79.62 $\pm$ 1.10	60.38 $\pm$ 3.66	80.63 $\pm$ 0.88
FA _{MCM} (Ours)	40.21 $\pm$ 2.76	91.47 $\pm$ 0.27	<u>71.30</u> $\pm$ 0.45	<u>77.08</u> $\pm$ 0.50	<u>66.33</u> $\pm$ 0.28	81.27 $\pm$ 0.53	59.28 $\pm$ 0.78	83.27 $\pm$ 0.29
FA _{GL} (Ours)	34.04 $\pm$ 1.45	92.17 $\pm$ 0.08	66.69 $\pm$ 0.29	78.24 $\pm$ 0.52	65.87 $\pm$ 0.38	79.20 $\pm$ 0.66	55.53 $\pm$ 0.47	<u>83.20</u> $\pm$ 0.37
4-shot								
CoOp _{MCM}	40.38 $\pm$ 3.63	91.40 $\pm$ 0.79	79.46 $\pm$ 1.49	72.18 $\pm$ 1.13	71.85 $\pm$ 1.93	80.01 $\pm$ 0.85	63.90 $\pm$ 2.22	81.19 $\pm$ 0.57
CoOp _{GL}	35.24 $\pm$ 2.38	91.27 $\pm$ 0.90	74.09 $\pm$ 1.31	74.56 $\pm$ 1.48	70.45 $\pm$ 1.15	76.23 $\pm$ 1.70	59.92 $\pm$ 1.47	80.69 $\pm$ 1.08
LoCoOp _{MCM}	40.10 $\pm$ 2.06	91.42 $\pm$ 0.69	79.06 $\pm$ 0.96	71.68 $\pm$ 0.68	72.46 $\pm$ 0.41	<u>80.95</u> $\pm$ 0.41	63.87 $\pm$ 1.13	81.35 $\pm$ 0.54
LoCoOp _{GL}	35.70 $\pm$ 1.60	91.91 $\pm$ 0.46	75.86 $\pm$ 0.37	72.12 $\pm$ 0.58	68.93 $\pm$ 1.78	80.85 $\pm$ 0.39	60.16 $\pm$ 1.19	81.63 $\pm$ 0.35
IDLike	55.76 $\pm$ 6.50	87.94 $\pm$ 0.90	78.82 $\pm$ 0.25	72.41 $\pm$ 1.74	83.46 $\pm$ 0.64	68.94 $\pm$ 1.64	72.68 $\pm$ 2.43	76.43 $\pm$ 0.79
SCT _{MCM}	41.15 $\pm$ 1.31	91.20 $\pm$ 0.17	80.75 $\pm$ 1.36	69.02 $\pm$ 1.26	73.37 $\pm$ 1.69	80.63 $\pm$ 0.84	65.09 $\pm$ 0.88	80.28 $\pm$ 0.47
SCT _{GL}	<u>35.09</u> $\pm$ 1.20	<u>91.98</u> $\pm$ 0.19	75.56 $\pm$ 0.92	71.44 $\pm$ 1.16	69.33 $\pm$ 1.39	80.05 $\pm$ 0.65	59.99 $\pm$ 0.92	81.17 $\pm$ 0.23
FA _{MCM} (Ours)	41.23 $\pm$ 1.49	91.18 $\pm$ 0.31	<u>70.43</u> $\pm$ 1.96	<u>77.40</u> $\pm$ 1.45	<u>64.93</u> $\pm$ 0.65	82.18 $\pm$ 0.25	<u>58.86</u> $\pm$ 0.98	<u>83.59</u> $\pm$ 0.49
FA _{GL} (Ours)	33.92 $\pm$ 0.59	91.99 $\pm$ 0.26	65.80 $\pm$ 1.93	78.84 $\pm$ 1.19	64.10 $\pm$ 1.06	80.09 $\pm$ 0.16	54.60 $\pm$ 0.77	83.64 $\pm$ 0.38

Table 9. Challenging ImageNet-1k OOD benchmark under the 1-shot and 4-shot settings. We use the same notation as Tab. 1.

B. More experimental details of OOD detection with other ID datasets

Referring to Section 5.2, we also use Food101 [3], StanfordCars [21], Caltech101 [12], FGVC Aircraft [29], Flowers102 [35], and OxfordPets [36] as ID datasets under the 16-shot setting. As shown in Tab. 10, using these ID datasets for OOD detection presents relatively lower difficulty, and our FA achieves superior OOD detection performance.

ID Dataset	Method	iNaturalist		SUN		Places		Textures		Average	
		FPR95↓	AUROC↑	FPR95↓	AUROC↑	FPR95↓	AUROC↑	FPR95↓	AUROC↑	FPR95↓	AUROC↑
Food101	CoOp _{MCM}	2.29 $\pm$ 1.20	99.35 $\pm$ 0.18	2.02 $\pm$ 0.47	99.49 $\pm$ 0.12	2.25 $\pm$ 0.79	99.43 $\pm$ 0.17	4.74 $\pm$ 0.53	98.53 $\pm$ 0.19	2.83 $\pm$ 0.46	99.19 $\pm$ 0.06
	CoOp _{GL}	0.43 $\pm$ 0.13	99.79 $\pm$ 0.02	0.81 $\pm$ 0.29	99.77 $\pm$ 0.05	0.75 $\pm$ 0.33	99.76 $\pm$ 0.07	4.44 $\pm$ 0.90	98.55 $\pm$ 0.32	1.61 $\pm$ 0.11	99.47 $\pm$ 0.04
	FA _{MCM} (Ours)	0.57 $\pm$ 0.06	99.77 $\pm$ 0.13	0.12 $\pm$ 0.07	99.93 $\pm$ 0.02	0.14 $\pm$ 0.11	99.92 $\pm$ 0.02	1.63 $\pm$ 0.15	99.64 $\pm$ 0.06	0.61 $\pm$ 0.13	99.81 $\pm$ 0.02
	FA _{GL} (Ours)	0.10 $\pm$ 0.07	99.90 $\pm$ 0.03	0.03 $\pm$ 0.02	99.95 $\pm$ 0.01	0.06 $\pm$ 0.04	99.95 $\pm$ 0.01	1.87 $\pm$ 0.22	99.56 $\pm$ 0.07	0.52 $\pm$ 0.05	99.84 $\pm$ 0.01
Stanford-Cars	CoOp _{MCM}	0.12 $\pm$ 0.02	99.83 $\pm$ 0.08	0.02 $\pm$ 0.01	99.97 $\pm$ 0.01	0.16 $\pm$ 0.03	99.94 $\pm$ 0.01	0.00 $\pm$ 0.00	99.97 $\pm$ 0.01	0.08 $\pm$ 0.06	99.93 $\pm$ 0.02
	CoOp _{GL}	0.06 $\pm$ 0.02	99.93 $\pm$ 0.03	0.04 $\pm$ 0.02	99.98 $\pm$ 0.01	0.20 $\pm$ 0.05	99.94 $\pm$ 0.01	0.01 $\pm$ 0.00	99.98 $\pm$ 0.01	0.08 $\pm$ 0.03	99.96 $\pm$ 0.02
	FA _{MCM} (Ours)	0.01 $\pm$ 0.00	99.89 $\pm$ 0.02	0.00 $\pm$ 0.00	99.99 $\pm$ 0.01	0.16 $\pm$ 0.06	99.94 $\pm$ 0.01	0.01 $\pm$ 0.01	99.98 $\pm$ 0.01	0.05 $\pm$ 0.02	99.95 $\pm$ 0.01
	FA _{GL} (Ours)	0.01 $\pm$ 0.01	99.94 $\pm$ 0.01	0.03 $\pm$ 0.02	99.98 $\pm$ 0.01	0.23 $\pm$ 0.02	99.92 $\pm$ 0.01	0.01 $\pm$ 0.01	99.98 $\pm$ 0.00	0.07 $\pm$ 0.01	99.95 $\pm$ 0.00
Caltech101	CoOp _{MCM}	19.09 $\pm$ 2.85	96.27 $\pm$ 0.55	6.27 $\pm$ 1.23	98.33 $\pm$ 0.25	11.18 $\pm$ 1.47	97.05 $\pm$ 0.41	6.33 $\pm$ 0.71	98.31 $\pm$ 0.12	10.72 $\pm$ 1.33	97.49 $\pm$ 0.31
	CoOp _{GL}	16.93 $\pm$ 8.92	96.60 $\pm$ 1.42	7.13 $\pm$ 2.93	98.28 $\pm$ 0.52	12.83 $\pm$ 4.12	96.89 $\pm$ 0.84	11.35 $\pm$ 1.75	97.52 $\pm$ 0.34	12.06 $\pm$ 4.35	97.33 $\pm$ 0.73
	FA _{MCM} (Ours)	10.82 $\pm$ 3.21	97.83 $\pm$ 0.51	4.16 $\pm$ 0.70	98.93 $\pm$ 0.20	6.66 $\pm$ 0.56	98.30 $\pm$ 0.19	3.74 $\pm$ 0.79	99.09 $\pm$ 0.18	6.35 $\pm$ 0.97	98.54 $\pm$ 0.19
	FA _{GL} (Ours)	6.54 $\pm$ 1.96	98.56 $\pm$ 0.29	4.44 $\pm$ 0.38	98.89 $\pm$ 0.11	7.02 $\pm$ 0.21	98.28 $\pm$ 0.05	4.49 $\pm$ 1.00	98.92 $\pm$ 0.17	5.62 $\pm$ 0.77	98.66 $\pm$ 0.11
FGVC-Aircraft	CoOp _{MCM}	43.96 $\pm$ 6.28	89.57 $\pm$ 1.36	18.31 $\pm$ 5.64	96.40 $\pm$ 0.95	21.97 $\pm$ 7.33	94.99 $\pm$ 1.36	17.41 $\pm$ 4.81	96.34 $\pm$ 0.89	25.41 $\pm$ 4.92	94.33 $\pm$ 0.81
	CoOp _{GL}	64.31 $\pm$ 8.29	81.60 $\pm$ 2.68	41.94 $\pm$ 8.24	90.56 $\pm$ 2.34	45.08 $\pm$ 8.21	88.59 $\pm$ 2.29	54.41 $\pm$ 9.95	84.72 $\pm$ 4.19	51.44 $\pm$ 7.16	86.37 $\pm$ 2.19
	FA _{MCM} (Ours)	7.07 $\pm$ 3.78	98.54 $\pm$ 0.65	0.49 $\pm$ 0.49	99.75 $\pm$ 0.16	1.70 $\pm$ 0.55	99.52 $\pm$ 0.18	0.58 $\pm$ 0.51	99.81 $\pm$ 0.12	2.46 $\pm$ 1.32	99.40 $\pm$ 0.27
	FA _{GL} (Ours)	20.61 $\pm$ 6.50	95.76 $\pm$ 1.37	2.83 $\pm$ 1.29	99.33 $\pm$ 0.27	3.96 $\pm$ 0.89	98.87 $\pm$ 0.26	3.69 $\pm$ 1.36	99.12 $\pm$ 0.34	7.77 $\pm$ 2.45	98.27 $\pm$ 0.53
Flowers102	CoOp _{MCM}	30.90 $\pm$ 1.80	92.38 $\pm$ 0.66	1.84 $\pm$ 1.58	99.57 $\pm$ 0.33	3.18 $\pm$ 1.68	99.21 $\pm$ 0.36	2.14 $\pm$ 0.56	99.53 $\pm$ 0.09	9.52 $\pm$ 1.19	97.67 $\pm$ 0.33
	CoOp _{GL}	33.32 $\pm$ 3.10	92.25 $\pm$ 0.79	2.56 $\pm$ 2.16	99.49 $\pm$ 0.39	3.96 $\pm$ 1.91	99.08 $\pm$ 0.38	4.29 $\pm$ 0.64	99.07 $\pm$ 0.16	11.03 $\pm$ 1.77	97.48 $\pm$ 0.39
	FA _{MCM} (Ours)	20.96 $\pm$ 4.09	95.23 $\pm$ 0.89	0.46 $\pm$ 0.07	99.87 $\pm$ 0.01	1.47 $\pm$ 0.19	99.62 $\pm$ 0.05	0.82 $\pm$ 0.13	99.78 $\pm$ 0.05	5.93 $\pm$ 1.09	98.63 $\pm$ 0.23
	FA _{GL} (Ours)	22.63 $\pm$ 4.45	94.93 $\pm$ 0.86	1.17 $\pm$ 0.20	99.71 $\pm$ 0.02	2.88 $\pm$ 0.25	99.29 $\pm$ 0.03	2.95 $\pm$ 0.54	99.27 $\pm$ 0.09	7.41 $\pm$ 1.28	98.29 $\pm$ 0.23
Oxford-Pets	CoOp _{MCM}	4.64 $\pm$ 1.58	99.02 $\pm$ 0.23	0.33 $\pm$ 0.31	99.90 $\pm$ 0.06	1.02 $\pm$ 0.32	99.77 $\pm$ 0.05	0.79 $\pm$ 0.23	99.82 $\pm$ 0.04	1.69 $\pm$ 0.55	99.63 $\pm$ 0.08
	CoOp _{GL}	2.88 $\pm$ 1.13	99.38 $\pm$ 0.18	0.31 $\pm$ 0.08	99.93 $\pm$ 0.05	0.98 $\pm$ 0.47	99.79 $\pm$ 0.07	1.80 $\pm$ 0.75	99.59 $\pm$ 0.15	1.49 $\pm$ 0.67	99.67 $\pm$ 0.11
	FA _{MCM} (Ours)	0.86 $\pm$ 0.60	99.73 $\pm$ 0.15	0.09 $\pm$ 0.06	99.94 $\pm$ 0.02	0.37 $\pm$ 0.12	99.90 $\pm$ 0.02	0.22 $\pm$ 0.14	99.94 $\pm$ 0.03	0.39 $\pm$ 0.22	99.88 $\pm$ 0.05
	FA _{GL} (Ours)	0.63 $\pm$ 0.42	99.80 $\pm$ 0.09	0.75 $\pm$ 0.08	99.81 $\pm$ 0.02	0.64 $\pm$ 0.10	99.84 $\pm$ 0.03	0.54 $\pm$ 0.28	99.85 $\pm$ 0.05	0.64 $\pm$ 0.21	99.82 $\pm$ 0.05

Table 10. Full numerical results of OOD detection performance with other ID datasets under the 16-shot setting. We use the same notation as Tab. 1.