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# Supplementary Materials for “Incremental Few-Shot Learning with Attention Attractor Networks”

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## 1 Regular Few-Shot Classification

We include standard 5-way few-shot classification results in Table 1. As mentioned in the main text, a simple logistic regression model can achieve competitive performance on few-shot classification using pretrained features. Our full model shows similar performance on regular few-shot classification. This confirms that the learned regularizer is mainly solving the interference problem between the base and novel classes.

Table 1: Regular 5-way few-shot classification on *mini-ImageNet*. Note that this is purely few-shot, with no base classes. Applying logistic regression on pretrained features achieves performance on-par with other competitive meta-learning approaches. \* denotes our own implementation.

Model	Backbone	1-shot	5-shot
MatchingNets [8]	C64	43.60	55.30
Meta-LSTM [5]	C32	43.40 $\pm$ 0.77	60.20 $\pm$ 0.71
MAML [2]	C64	48.70 $\pm$ 1.84	63.10 $\pm$ 0.92
RelationNet [7]	C64	50.44 $\pm$ 0.82	65.32 $\pm$ 0.70
R2-D2 [1]	C256	51.20 $\pm$ 0.60	68.20 $\pm$ 0.60
SNAIL [4]	ResNet	55.71 $\pm$ 0.99	68.88 $\pm$ 0.92
ProtoNet [6]	C64	49.42 $\pm$ 0.78	68.20 $\pm$ 0.66
ProtoNet* [6]	ResNet	50.09 $\pm$ 0.41	70.76 $\pm$ 0.19
LwoF [3]	ResNet	55.45 $\pm$ 0.89	<b>70.92</b> $\pm$ 0.35
LR	ResNet	55.40 $\pm$ 0.51	70.17 $\pm$ 0.46
Ours Full	ResNet	<b>55.75</b> $\pm$ 0.51	70.14 $\pm$ 0.44

## 2 Visualization of Few-Shot Episodes

We include more visualization of few-shot episodes in Figure 1, highlighting the differences between our method and “Dynamic Few-Shot Learning without Forgetting” [3].

## 3 Visualization of Attention Attractors

To further understand the attractor mechanism, we picked 5 semantic classes in *mini-ImageNet* and visualized their the attention attractors across 20 episodes, shown in Figure 2. The attractors roughly form semantic clusters, whereas the static attractor stays in the center of all attractors.

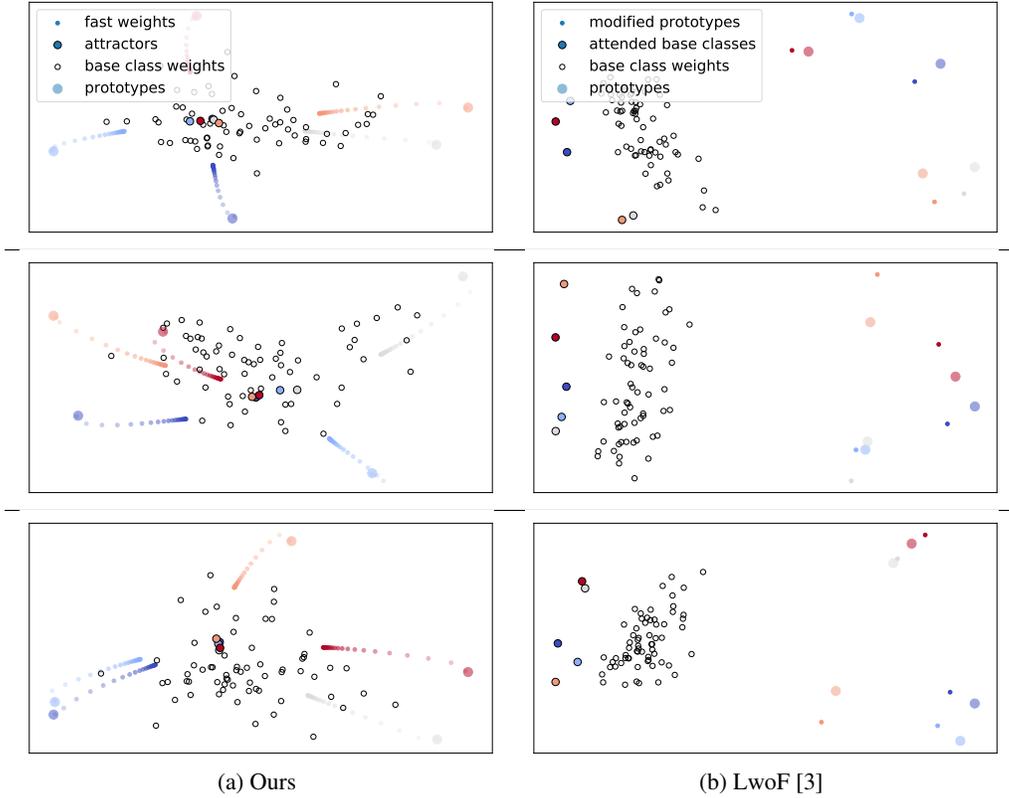


Figure 1: Visualization of 5-shot 64+5-way episodes on *mini-ImageNet* using PCA.

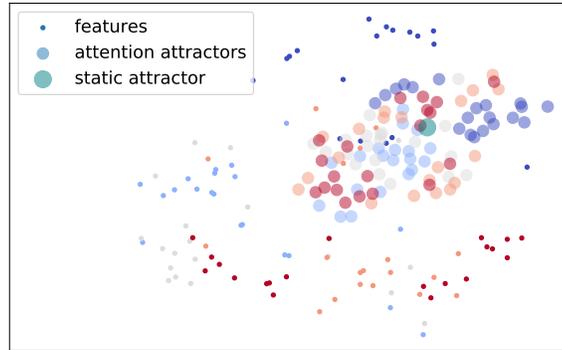


Figure 2: Visualization of example features and attractors using t-SNE. This plot shows a 5-way 5-shot episode on *mini-ImageNet*. 512-dimensional feature vectors and attractor vectors are projected to a 2-dim space. Color represents the label class of the example. The static attractor (teal) appears at the center of the attention attractors, which roughly form clusters based on the classes.

## 14 4 Dataset Statistics

15 In this section, we include more details on the datasets we used in our experiments.

### 16 4.1 Validation and testing splits for base classes

17 In standard few-shot learning, meta-training, validation, and test set have disjoint sets of object  
 18 classes. However, in our incremental few-shot learning setting, to evaluate the model performance on  
 19 the base class predictions, additional splits of validation and test splits of the meta-training set are  
 20 required. Splits and dataset statistics are listed in Table 4. For *mini-ImageNet*, [3] released additional

Table 2: Full ablation results on 64+5-way *mini*-ImageNet

	1-shot				5-shot			
	Acc. $\uparrow$	$\Delta \downarrow$	$\Delta_a \downarrow$	$\Delta_b \downarrow$	Acc. $\uparrow$	$\Delta \downarrow$	$\Delta_a \downarrow$	$\Delta_b \downarrow$
LR	52.74 $\pm$ 0.24	-13.95	-8.98	-24.32	60.34 $\pm$ 0.20	-13.60	-10.81	-15.97
LR+S	53.63 $\pm$ 0.30	-12.53	-9.44	-15.62	62.50 $\pm$ 0.30	-11.29	-13.84	-8.75
LR+A	<b>55.31</b> $\pm$ 0.32	<b>-11.72</b>	-12.72	-10.71	63.00 $\pm$ 0.29	-10.80	-13.59	-8.01
MLP	49.36 $\pm$ 0.29	-16.78	-8.95	-24.61	60.85 $\pm$ 0.29	-12.62	-11.35	-13.89
MLP+S	54.46 $\pm$ 0.31	-11.74	-12.73	-10.74	62.79 $\pm$ 0.31	-10.77	-12.61	-8.80
MLP+A	54.95 $\pm$ 0.30	-11.84	-12.81	-10.87	<b>63.04</b> $\pm$ 0.30	<b>-10.66</b>	-12.55	-8.77

Table 3: Full ablation results on 200+5-way *tiered*-ImageNet

	1-shot				5-shot			
	Acc. $\uparrow$	$\Delta \downarrow$	$\Delta_a \downarrow$	$\Delta_b \downarrow$	Acc. $\uparrow$	$\Delta \downarrow$	$\Delta_a \downarrow$	$\Delta_b \downarrow$
LR	48.84 $\pm$ 0.23	-10.44	-11.65	-9.24	62.08 $\pm$ 0.20	-8.00	-5.49	-10.51
LR+S	55.36 $\pm$ 0.32	-6.88	-7.21	-6.55	65.53 $\pm$ 0.30	-4.68	-4.72	-4.63
LR+A	55.98 $\pm$ 0.32	<b>-6.07</b>	-6.64	-5.51	65.58 $\pm$ 0.29	<b>-4.39</b>	-4.87	-3.91
MLP	41.22 $\pm$ 0.35	-10.61	-11.25	-9.98	62.70 $\pm$ 0.31	-7.44	-6.05	-8.82
MLP+S	<b>56.16</b> $\pm$ 0.32	-6.28	-6.83	-5.73	<b>65.80</b> $\pm$ 0.31	-4.58	-4.66	-4.51
MLP+A	56.11 $\pm$ 0.33	6.11	-6.79	-5.43	65.52 $\pm$ 0.31	-4.48	-4.91	-4.05

21 images for evaluating training set, namely ‘‘Train-Val’’ and ‘‘Train-Test’’. For *tiered*-ImageNet, we  
 22 split out  $\approx 20\%$  of the images for validation and testing of the base classes.

## 23 4.2 Novel classes

24 In *mini*-ImageNet experiments, the same training set is used for both  $\mathcal{D}_a$  and  $\mathcal{D}_b$ . In order to pretend  
 25 that the classes in the few-shot episode are novel, following [3], we masked the base classes in  $W_a$ ,  
 26 which contains 64 base classes. In other words, we essentially train for a 59+5 classification task. We  
 27 found that under this setting, the progress of meta-learning in the second stage is not very significant,  
 28 since all classes have already been seen before.

29 In *tiered*-ImageNet experiments, to emulate the process of learning novel classes during the second  
 30 stage, we split the training classes into base classes (‘‘Train-A’’) with 200 classes and novel classes  
 31 (‘‘Train-B’’) with 151 classes, just for meta-learning purpose. During the first stage the classifier is  
 32 trained using Train-A-Train data. In each meta-learning episode we sample few-shot examples from  
 33 the novel classes (Train-B) and a query base set from Train-A-Val.

### 34 200 Base Classes (‘‘Train-A’’):

35 n02128757, n02950826, n01694178, n01582220, n03075370, n01531178, n03947888,  
 36 n03884397, n02883205, n03788195, n04141975, n02992529, n03954731, n03661043,  
 37 n04606251, n03344393, n01847000, n03032252, n02128385, n04443257, n03394916,  
 38 n01592084, n02398521, n01748264, n04355338, n02481823, n03146219, n02963159,  
 39 n02123597, n01675722, n03637318, n04136333, n02002556, n02408429, n02415577,  
 40 n02787622, n04008634, n02091831, n02488702, n04515003, n04370456, n02093256,  
 41 n01693334, n02088466, n03495258, n02865351, n01688243, n02093428, n02410509,  
 42 n02487347, n03249569, n03866082, n04479046, n02093754, n01687978, n04350905,  
 43 n02488291, n02804610, n02094433, n03481172, n01689811, n04423845, n03476684,  
 44 n04536866, n01751748, n02028035, n03770439, n04417672, n02988304, n03673027,  
 45 n02492660, n03840681, n02011460, n03272010, n02089078, n03109150, n03424325,  
 46 n02002724, n03857828, n02007558, n02096051, n01601694, n04273569, n02018207,  
 47 n01756291, n04208210, n03447447, n02091467, n02089867, n02089973, n03777754,  
 48 n04392985, n02125311, n02676566, n02092002, n02051845, n04153751, n02097209,  
 49 n04376876, n02097298, n04371430, n03461385, n04540053, n04552348, n02097047,  
 50 n02494079, n03457902, n02403003, n03781244, n02895154, n02422699, n04254680,  
 51 n02672831, n02483362, n02690373, n02092339, n02879718, n02776631, n04141076,  
 52 n03710721, n03658185, n01728920, n02009229, n03929855, n03721384, n03773504,  
 53 n03649909, n04523525, n02088632, n04347754, n02058221, n02091635, n02094258,  
 54 n01695060, n02486410, n03017168, n02910353, n03594734, n02095570, n03706229,

Table 4: *mini*-ImageNet and *tiered*-ImageNet split statistics

Classes	Purpose	<i>mini</i> -ImageNet			<i>tiered</i> -ImageNet		
		Split	N. Cls	N. Img	Split	N. Cls	N. Img
Base	Train	Train-Train	64	38,400	Train-A-Train	200	203,751
	Val	Train-Val	64	18,748	Train-A-Val	200	25,460
	Test	Train-Test	64	19,200	Train-A-Test	200	25,488
Novel	Train	Train-Train	64	38,400	Train-B	151	193,996
	Val	Val	16	9,600	Val	97	124,261
	Test	Test	20	12,000	Test	160	206,209

55 n02791270, n02127052, n02009912, n03467068, n02094114, n03782006, n01558993,  
 56 n03841143, n02825657, n03110669, n03877845, n02128925, n02091032, n03595614,  
 57 n01735189, n04081281, n04328186, n03494278, n02841315, n03854065, n03498962,  
 58 n04141327, n02951585, n02397096, n02123045, n02095889, n01532829, n02981792,  
 59 n02097130, n04317175, n04311174, n03372029, n04229816, n02802426, n03980874,  
 60 n02486261, n02006656, n02025239, n03967562, n03089624, n02129165, n01753488,  
 61 n02124075, n02500267, n03544143, n02687172, n02391049, n02412080, n04118776,  
 62 n03838899, n01580077, n04589890, n03188531, n03874599, n02843684, n02489166,  
 63 n01855672, n04483307, n02096177, n02088364.

64 **151 Novel Classes (“Train-B”):**

65 n03720891, n02090379, n03134739, n03584254, n02859443, n03617480, n01677366,  
 66 n02490219, n02749479, n04044716, n03942813, n02692877, n01534433, n02708093,  
 67 n03804744, n04162706, n04590129, n04356056, n01729322, n02091134, n03788365,  
 68 n01739381, n02727426, n02396427, n03527444, n01682714, n03630383, n04591157,  
 69 n02871525, n02096585, n02093991, n02013706, n04200800, n04090263, n02493793,  
 70 n03529860, n02088238, n02992211, n03657121, n02492035, n03662601, n04127249,  
 71 n03197337, n02056570, n04005630, n01537544, n02422106, n02130308, n03187595,  
 72 n03028079, n02098413, n02098105, n02480855, n02437616, n02123159, n03803284,  
 73 n02090622, n02012849, n01744401, n06785654, n04192698, n02027492, n02129604,  
 74 n02090721, n02395406, n02794156, n01860187, n01740131, n02097658, n03220513,  
 75 n04462240, n01737021, n04346328, n04487394, n03627232, n04023962, n03598930,  
 76 n03000247, n04009552, n02123394, n01729977, n02037110, n01734418, n02417914,  
 77 n02979186, n01530575, n03534580, n03447721, n04118538, n02951358, n01749939,  
 78 n02033041, n04548280, n01755581, n03208938, n04154565, n02927161, n02484975,  
 79 n03445777, n02840245, n02837789, n02437312, n04266014, n03347037, n04612504,  
 80 n02497673, n03085013, n02098286, n03692522, n04147183, n01728572, n02483708,  
 81 n04435653, n02480495, n01742172, n03452741, n03956157, n02667093, n04409515,  
 82 n02096437, n01685808, n02799071, n02095314, n04325704, n02793495, n03891332,  
 83 n02782093, n02018795, n03041632, n02097474, n03404251, n01560419, n02093647,  
 84 n03196217, n03325584, n02493509, n04507155, n03970156, n02088094, n01692333,  
 85 n01855032, n02017213, n02423022, n03095699, n04086273, n02096294, n03902125,  
 86 n02892767, n02091244, n02093859, n02389026.

87 **References**

88 [1] L. Bertinetto, J. F. Henriques, P. H. S. Torr, and A. Vedaldi. Meta-learning with differentiable  
 89 closed-form solvers. *CoRR*, abs/1805.08136, 2018.

90 [2] C. Finn, P. Abbeel, and S. Levine. Model-agnostic meta-learning for fast adaptation of deep  
 91 networks. In *Proceedings of the 34th International Conference on Machine Learning (ICML)*,  
 92 2017.

93 [3] S. Gidaris and N. Komodakis. Dynamic few-shot visual learning without forgetting. In  
 94 *Proceedings of the IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*,  
 95 2018.

- 96 [4] N. Mishra, M. Rohaninejad, X. Chen, and P. Abbeel. A simple neural attentive meta-learner. In  
97 *Proceedings of the 6th International Conference on Learning Representations (ICLR)*, 2018.
- 98 [5] S. Ravi and H. Larochelle. Optimization as a model for few-shot learning. In *Proceedings of the*  
99 *5th International Conference on Learning Representations (ICLR)*, 2017.
- 100 [6] J. Snell, K. Swersky, and R. S. Zemel. Prototypical networks for few-shot learning. In *Advances*  
101 *in Neural Information Processing Systems 30 (NIPS)*, 2017.
- 102 [7] F. Sung, Y. Yang, L. Zhang, T. Xiang, P. H. S. Torr, and T. M. Hospedales. Learning to compare:  
103 Relation network for few-shot learning. In *Proceedings of the IEEE Conference on Computer*  
104 *Vision and Pattern Recognition (CVPR)*, 2018.
- 105 [8] O. Vinyals, C. Blundell, T. Lillicrap, K. Kavukcuoglu, and D. Wierstra. Matching networks for  
106 one shot learning. In *Advances in Neural Information Processing Systems 29 (NIPS)*, 2016.