



# Data Augmentation for Meta-Learning

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Jun, 2021

# A Brief Synopsis

- Strong data augmentations are known to improve performance in many tasks.
- Meta-learning has tons of moving parts which can be augmented: **support data, query data, tasks, shot**
- Meta-learners are very sensitive to the amount of query data and number of tasks and are less sensitive to the amount of support data.
- We augment each separately to study the impact on meta-learning.
- We propose Meta-MaxUp, an augmentation strategy that improves meta-learning performance by significant margins.

# Where Does Dataset Diversity Matter Most?

Support	Query	Task	1-shot	5-shot
600	600	full	$71.73 \pm 0.37$	$84.39 \pm 0.25$
5	600	full	$70.97 \pm 0.36$	$84.51 \pm 0.24$
5 (random)	600	full	$58.15 \pm 0.36$	$76.26 \pm 0.27$
600	5	full	$60.25 \pm 0.37$	$77.05 \pm 0.28$
600	600	13	$68.24 \pm 0.38$	$81.77 \pm 0.26$

Few-shot classification accuracy (%) using R2-D2 and a ResNet-12 backbone for various data size manipulations on CIFAR-FS. "Support", "Query" and "Task" columns denote the number of samples per class for support and query data and the number of total tasks available for sampling.

# Comparing Augmentation Modes

Mode	Level	CNN-4		ResNet-12	
		1-shot	5-shot	1-shot	5-shot
Baseline	-	67.56 $\pm$ 0.35	82.39 $\pm$ 0.26	73.01 $\pm$ 0.37	84.29 $\pm$ 0.24
CutMix	Support	69.05 $\pm$ 0.36	83.12 $\pm$ 0.26	72.79 $\pm$ 0.37	84.70 $\pm$ 0.25
Self-Mix	Support	69.61 $\pm$ 0.35	83.43 $\pm$ 0.25	71.96 $\pm$ 0.36	84.84 $\pm$ 0.25
CutMix	Query	<b>70.54 <math>\pm</math> 0.33</b>	<b>84.69 <math>\pm</math> 0.24</b>	<b>75.97 <math>\pm</math> 0.34</b>	<b>87.28 <math>\pm</math> 0.23</b>
Random Erase	Query	69.73 $\pm$ 0.34	84.04 $\pm$ 0.25	73.05 $\pm$ 0.36	85.67 $\pm$ 0.25
Self-Mix	Query	69.54 $\pm$ 0.35	84.20 $\pm$ 0.24	73.59 $\pm$ 0.35	86.14 $\pm$ 0.24
MixUp	Task	67.21 $\pm$ 0.35	82.72 $\pm$ 0.26	72.05 $\pm$ 0.37	85.27 $\pm$ 0.25
Large Rotation	Task	68.96 $\pm$ 0.35	83.65 $\pm$ 0.25	73.79 $\pm$ 0.36	85.81 $\pm$ 0.24
Horizontal Flip	Shot	68.13 $\pm$ 0.35	82.95 $\pm$ 0.25	73.25 $\pm$ 0.36	85.06 $\pm$ 0.25
Random Crop	Shot	67.33 $\pm$ 0.36	83.04 $\pm$ 0.25	70.56 $\pm$ 0.37	83.87 $\pm$ 0.25

Few-shot classification accuracy (%) on the CIFAR-FS dataset with the most effective data augmentations for each mode shown.

# Meta-MaxUp

- RL strategies and MaxUp have been proposed for augmenting data in image classification.
- RL strategies are not computationally feasible for meta-learning.
- Meta-MaxUp: try many augmentation strategies on each batch, choose ones that maximize loss.
- Each batch, several augmentations and their combinations are sampled and applied to support and query data.
- Select the augmentations that maximize query loss.

# Meta-MaxUp

Method	CIFAR-FS		mini-ImageNet	
	1-shot	5-shot	1-shot	5-shot
M-SVM Baseline	70.99 $\pm$ 0.37	84.00 $\pm$ 0.25	60.01 $\pm$ 0.32	77.42 $\pm$ 0.23
M-SVM + LargeRot	72.95 $\pm$ 0.24	85.91 $\pm$ 0.18	62.12 $\pm$ 0.22	78.90 $\pm$ 0.17
M-SVM + LargeRot + ens	75.85 $\pm$ 0.24	87.73 $\pm$ 0.17	64.56 $\pm$ 0.22	81.35 $\pm$ 0.16
M-SVM + DA (ours)	74.56 $\pm$ 0.34	87.61 $\pm$ 0.23	64.94 $\pm$ 0.33	82.10 $\pm$ 0.23
M-SVM + MM (ours)	75.67 $\pm$ 0.34	88.37 $\pm$ 0.23	65.02 $\pm$ 0.32	82.42 $\pm$ 0.23
M-SVM + MM + ens (ours)	<b>76.38 <math>\pm</math> 0.33</b>	<b>89.16 <math>\pm</math> 0.22</b>	<b>66.42 <math>\pm</math> 0.32</b>	<b>83.69 <math>\pm</math> 0.21</b>
M-SVM + MM + ens + val (ours)	<b>76.38 <math>\pm</math> 0.34</b>	<b>89.25 <math>\pm</math> 0.21</b>	<b>67.37 <math>\pm</math> 0.32</b>	<b>84.57 <math>\pm</math> 0.21</b>

“M-SVM” denotes MetaOptNet with the SVM head. “DA” denotes training with CutMix query augmentation and rotation task augmentation. “LargeRot” denotes large rotation augmentation as in Liu et al. 2020.

# Out-of-Distribution Testing on Meta-Dataset

Test Source	R2-D2	+ DA	+ MM	MetaOptNet	+ DA	+ MM
ILSVRC	69.04 $\pm$ 0.31	70.30 $\pm$ 0.31	<b>71.68 <math>\pm</math> 0.30</b>	68.92 $\pm$ 0.30	71.17 $\pm$ 0.30	<b>72.19 <math>\pm</math> 0.30</b>
Birds	75.22 $\pm$ 0.30	77.27 $\pm$ 0.28	<b>77.95 <math>\pm</math> 0.30</b>	75.58 $\pm$ 0.39	<b>77.49 <math>\pm</math> 0.29</b>	77.47 $\pm$ 0.2
OmniGlot	<b>97.46 <math>\pm</math> 0.08</b>	96.10 $\pm$ 0.11	96.71 $\pm$ 0.09	<b>97.43 <math>\pm</math> 0.10</b>	95.97 $\pm$ 0.10	96.59 $\pm$ 0.09
Aircraft	54.28 $\pm$ 0.28	58.93 $\pm$ 0.30	<b>60.83 <math>\pm</math> 0.28</b>	53.40 $\pm$ 0.37	60.43 $\pm$ 0.29	<b>60.57 <math>\pm</math> 0.29</b>
Textures	63.47 $\pm$ 0.24	65.98 $\pm$ 0.24	<b>67.34 <math>\pm</math> 0.26</b>	63.29 $\pm$ 0.33	65.70 $\pm$ 0.24	<b>69.42 <math>\pm</math> 0.25</b>
Quick Draw	76.39 $\pm$ 0.27	78.44 $\pm$ 0.27	<b>80.83 <math>\pm</math> 0.25</b>	78.00 $\pm$ 0.33	79.56 $\pm$ 0.25	<b>80.67 <math>\pm</math> 0.25</b>
Fungi	50.41 $\pm$ 0.22	52.29 $\pm$ 0.20	<b>54.12 <math>\pm</math> 0.22</b>	50.56 $\pm$ 0.21	53.80 $\pm$ 0.22	<b>53.82 <math>\pm</math> 0.22</b>
VGG Flower	86.26 $\pm$ 0.21	87.79 $\pm$ 0.19	<b>90.29 <math>\pm</math> 0.17</b>	88.16 $\pm$ 0.25	89.92 $\pm$ 0.18	<b>91.13 <math>\pm</math> 0.15</b>
Traffic Signs	83.98 $\pm$ 0.34	<b>84.23 <math>\pm</math> 0.36</b>	83.59 $\pm$ 0.36	85.12 $\pm$ 0.33	<b>85.25 <math>\pm</math> 0.33</b>	83.38 $\pm$ 0.37
MSCOCO	70.29 $\pm$ 0.30	71.59 $\pm$ 0.31	<b>72.83 <math>\pm</math> 0.29</b>	69.52 $\pm$ 0.32	71.90 $\pm$ 0.31	<b>73.49 <math>\pm</math> 0.30</b>

Few-shot classification accuracy (%) on Meta-Dataset with both MetaOptNet and R2-D2 learner. "+ DA" denotes training with CutMix (Q) + Rotation (T), and "+ MM" denotes training with Meta-MaxUp.