Bayesian Neural Networks for K-Shot Learning

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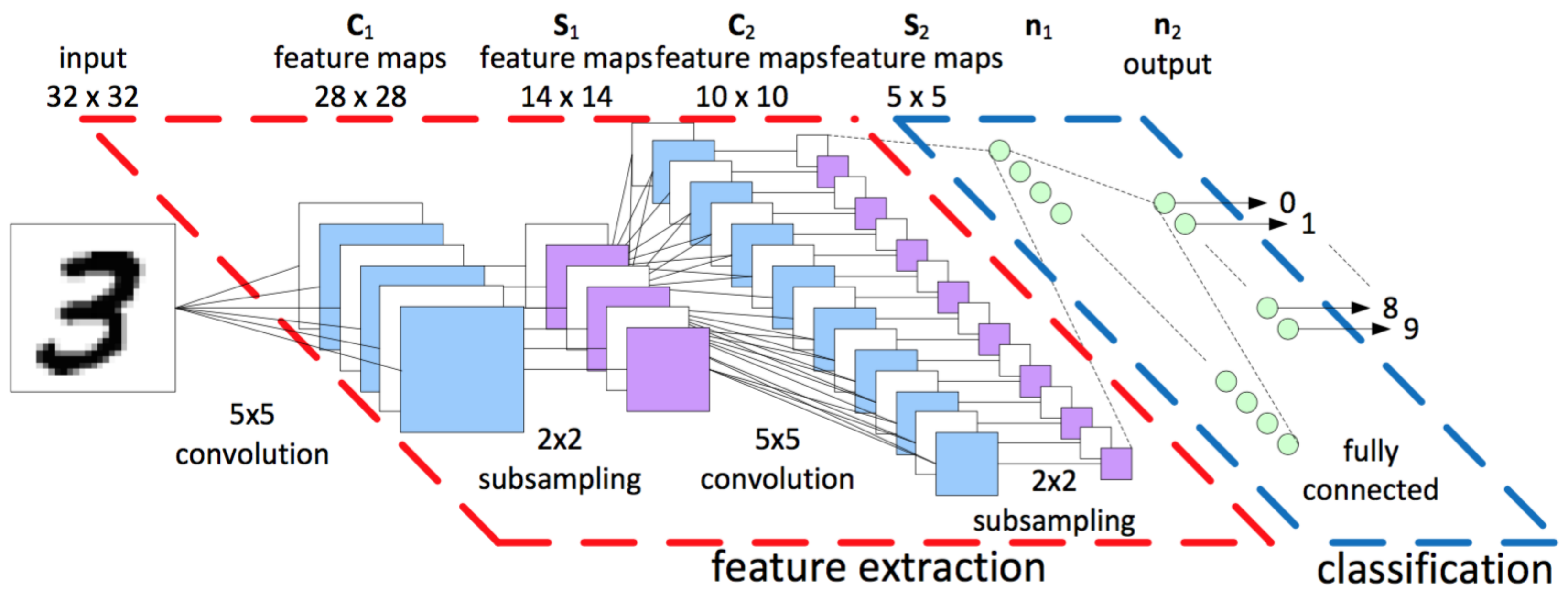
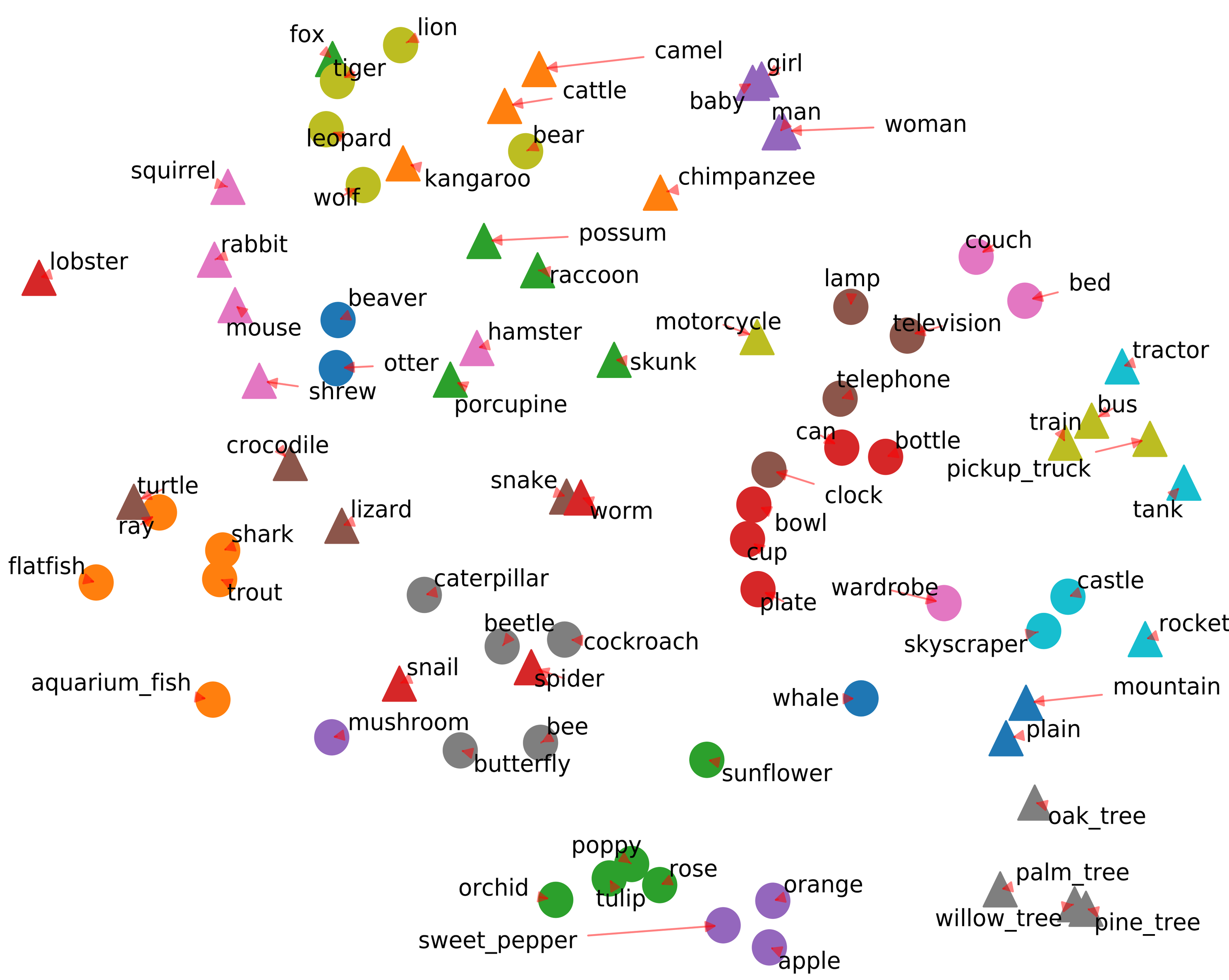
Concept learning with convolutional neural networks

- Extract features using convolutional neural networks (CNNs).
- Use the extracted features as inputs in probabilistic modelling.
- Below image by [5].

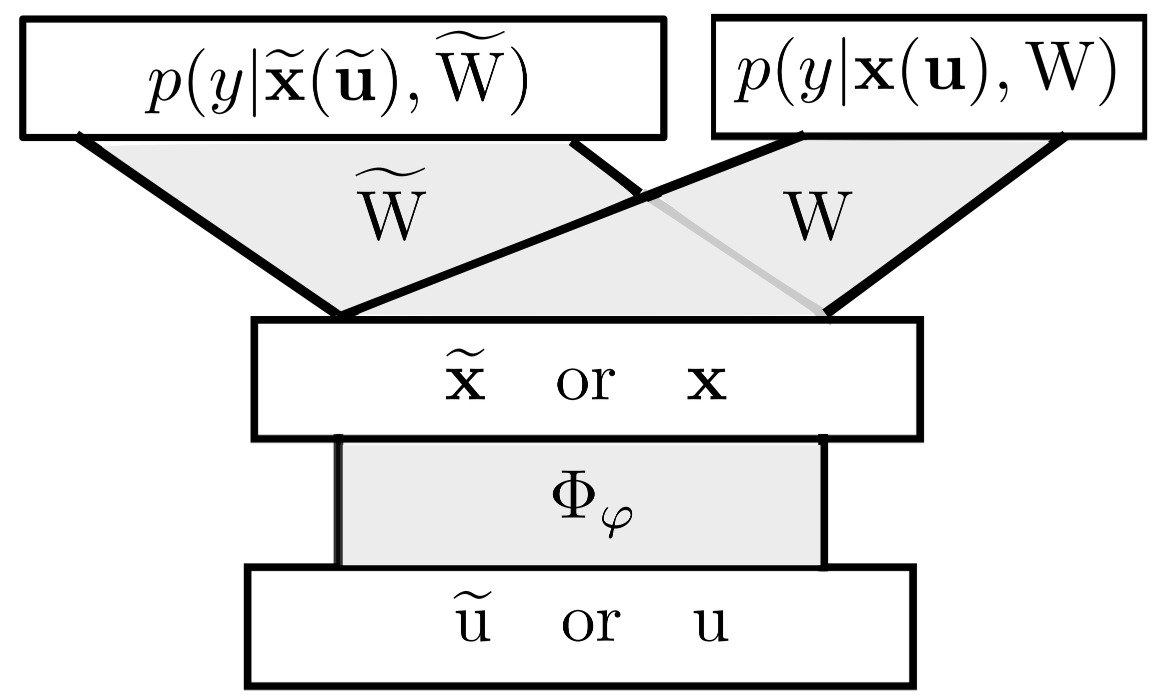


- Similar classes (e.g. belonging to the same superclass) have last layer weights that are also close in the t-SNE embedding space.
- This indicates usage of the similar concepts across similar classes.

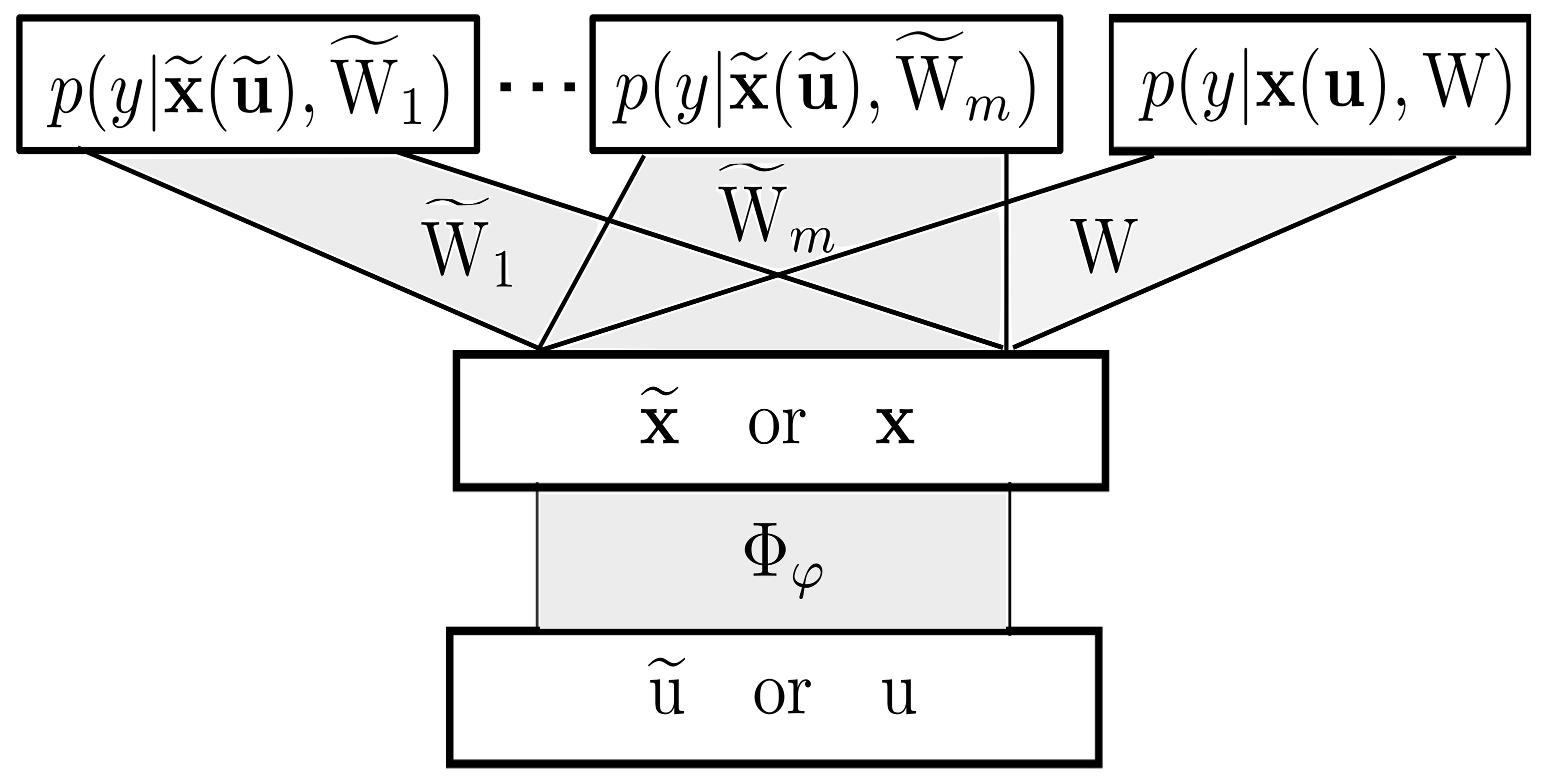


Concept learning architecture

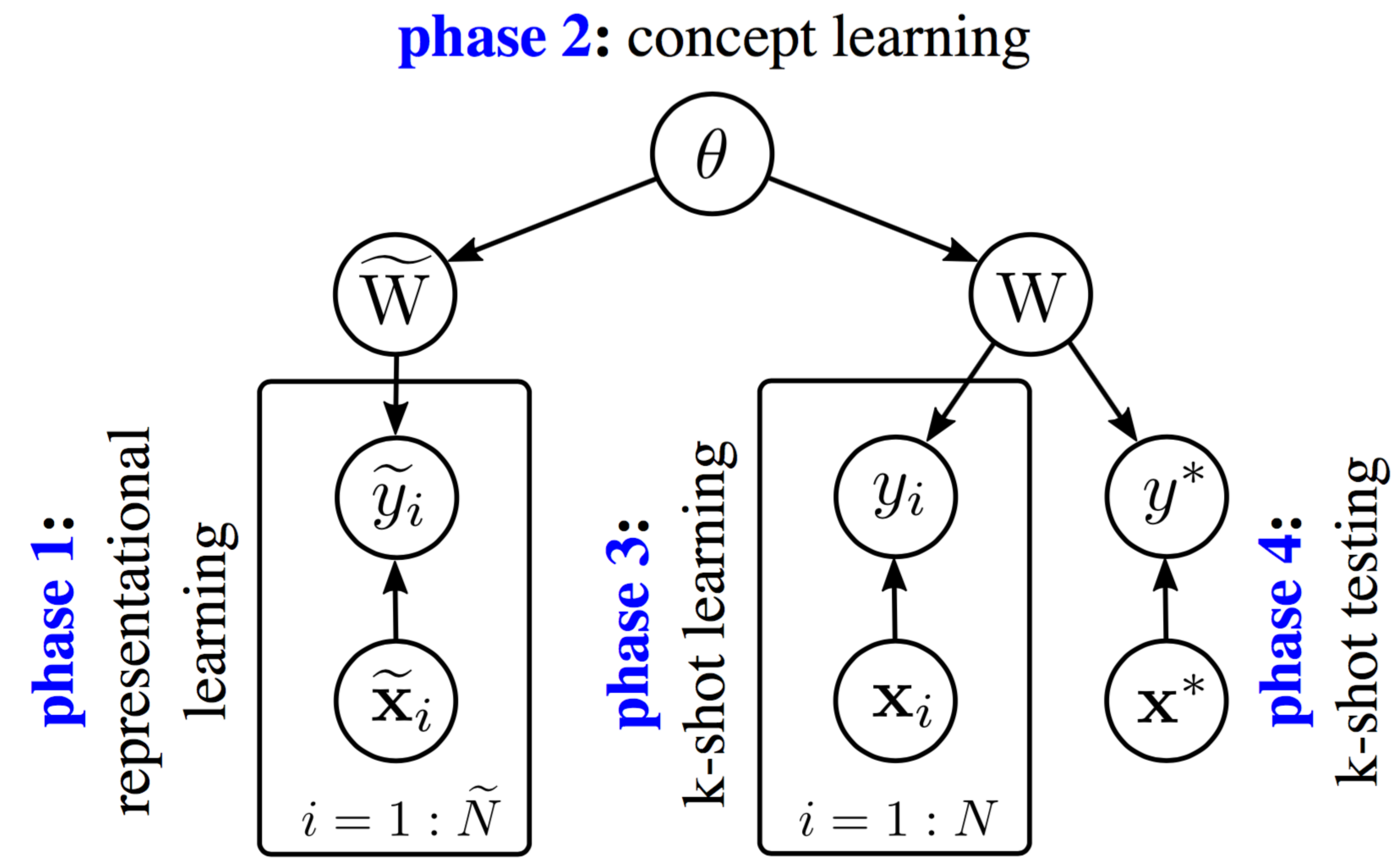
1. Train CNN on a subset of all classes (**training classes**).
2. Fix CNN weights up to the last hidden layer.
3. Train softmax weights for the rest of the classes (**test classes**).



In a new approach we train CNNs on **lots of subsets** of the training classes with shared parameters up to final hidden layer.

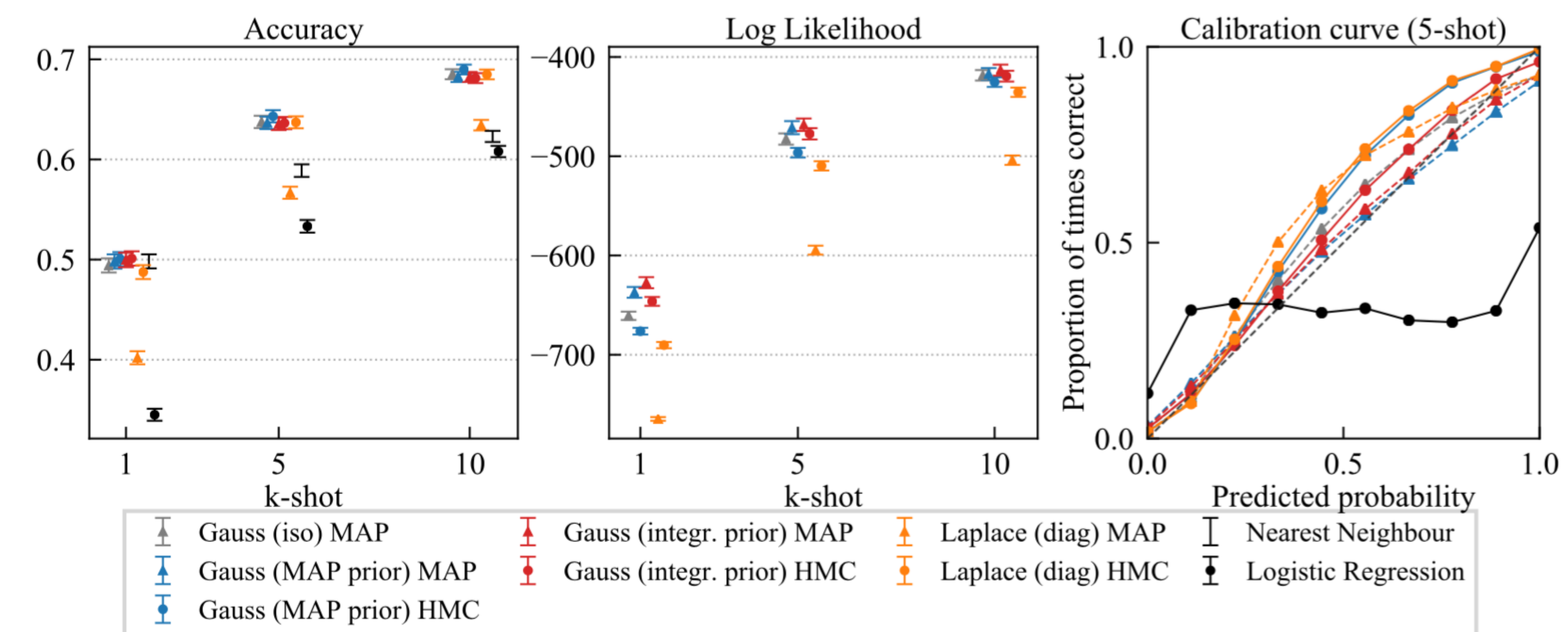


Probabilistic k-shot learning



Phase 1 learns a mapping to feature space and last layer weights for old classes.
Phase 2 learns a prior for the weights based on the weights from the old classes.
Phase 3 learns weights for the new classes based on the prior and K examples.
Phase 4 inferes classes for test examples from the new classes.

Comparison of inference methods



Comparison of models for the prior

Model	Optimised held-out neg. log prob.
Gauss (isotropic)	-1759 ± 3
Gauss (integr. prior)	-2006 ± 4
GMM super (iso)	-1309 ± 4
GMM super (full)	-1426 ± 5
GMM 3-means (iso)	-1090 ± 8
GMM 3-means (diag)	-1000 ± 12
GMM 10-means iso	-928 ± 13
Laplace (diag)	-1766 ± 5

−2,000 −1,000 0

Comparison to existing k-shot learning algorithms

Method	1-shot	5-shot
Matching Networks [3]*	43.4 + 0.8%	51.1 + 0.7%
Matching Networks FCE [3]*	43.6 + 0.8%	55.3 + 0.7%
Meta-Learner LSTM [11]	43.4 + 0.8%	60.6 + 0.7%
Prototypical Nets (1-shot) [4]	49.4 + 0.8%	65.4 + 0.7%
Prototypical Nets (5-shot) [4]	45.1 + 0.8%	68.2 + 0.7%
Gauss (MAP pr.) HMC (ours)	50.0 + 0.5%	64.3 + 0.6%

References

[1] Bauer, M., Rojar-Carulla, M., Swiatkowski, J.B., Scholkopf, B., Turner, R.E., 2017. arXiv: 1706.00326.
[2] Lake, B.M., Salakhutdinov, R. and Tenenbaum, J.B., 2015. Science, 350(6266).
[3] Srivastava, N. and Salakhutdinov, R.R., 2013. In Advances in NIPS (pp. 2094-2102).
[4] Burgess, J., Lloyd, J.R. and Ghahramani, Z., 2016.
[5] Peemen, M., Mesman, B. and Corporaal, H., 2011. In Proceedings of the 8th International Automotive Congress (pp. 162-170).