Computer Engineering Department

Multi-Task Learning and Meta-Learning: Introduction and terminology

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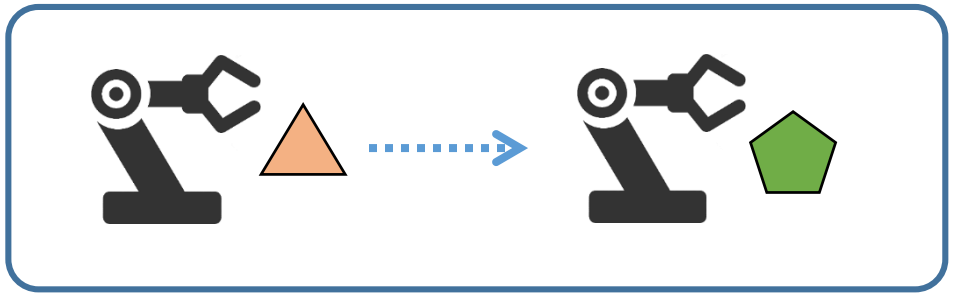
Introduction

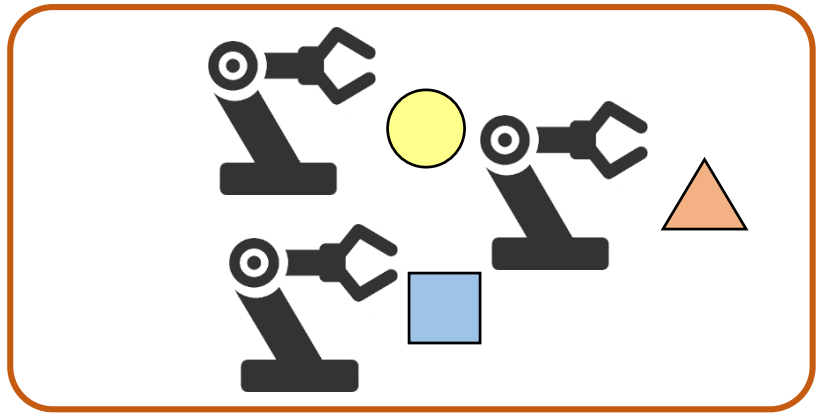
- Assumption: Tasks share common structure
- Goal: Use experience (common knowledge) from other tasks to improve learning another tasks
- Benefits:
  - Accelerate learning procedure
  - Mitigate lack of data (sample efficiency)
- Type of problem settings:
  - Multi-task learning
  - Transfer learning
  - Meta-learning

Problem Settings

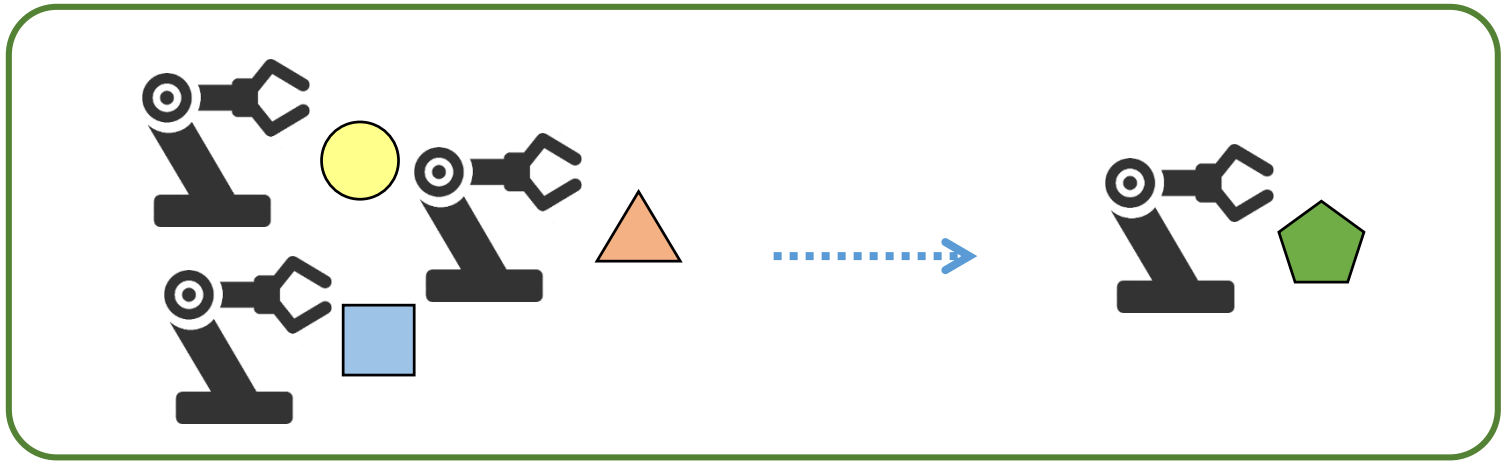
Transfer Learning



Multi-Task Learning



Meta-Learning



Problem Settings

Transfer Learning

Solve target task after solving source task.

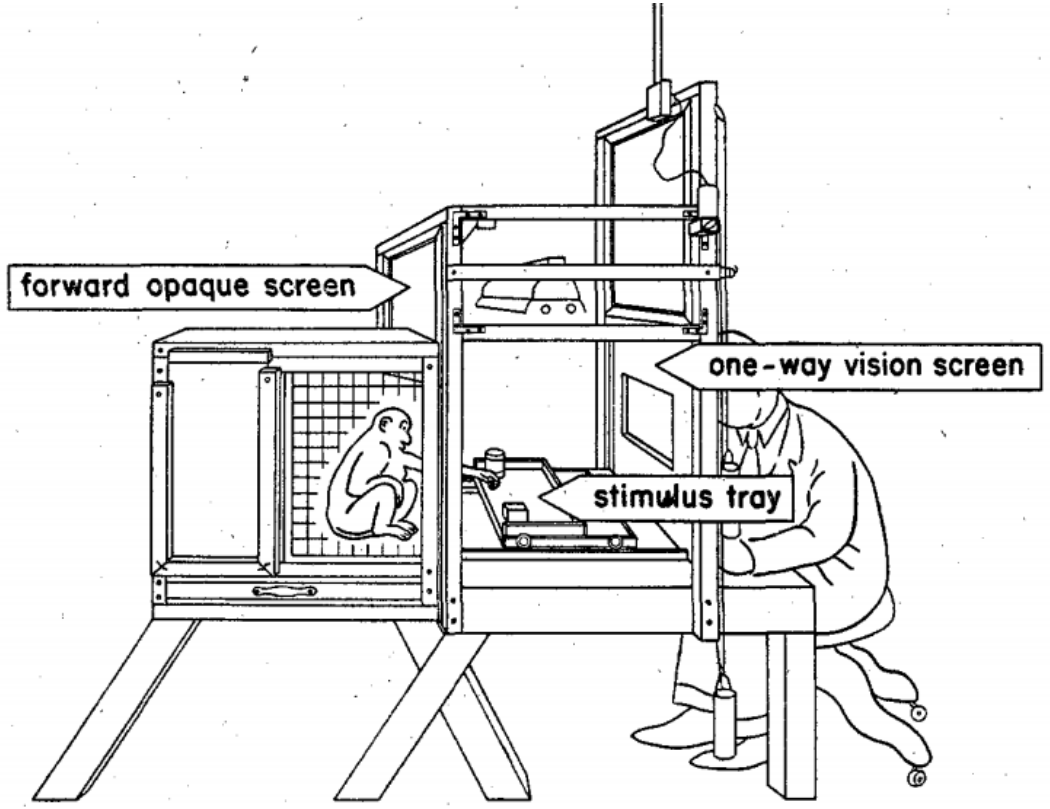
Multi-Task Learning

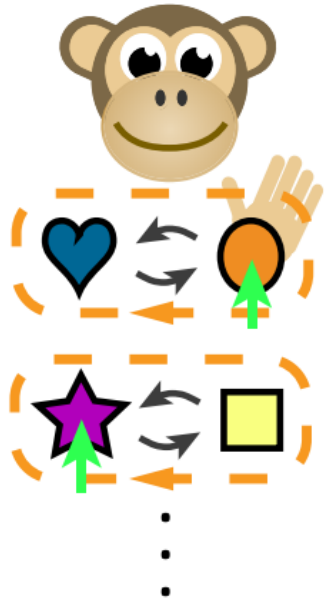
Solve multiple tasks at once.

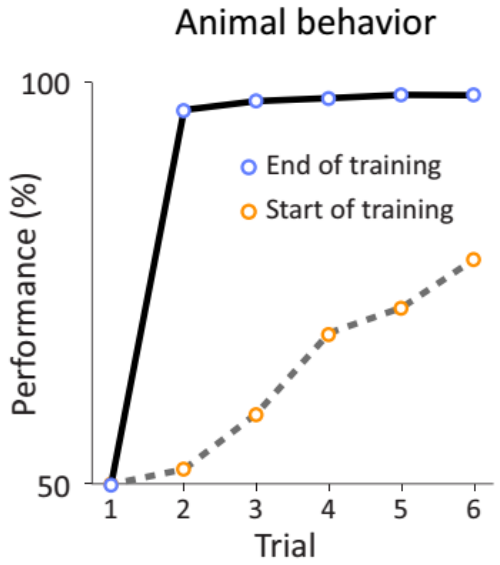
Meta-Learning

Given multiple tasks, solve new task quickly / efficiently.

Meta-Learning: Learning to Learn







[H. F. Harlow, "The formation of learning sets.," Psychological review, 1949.]

Meta-Learning VS. Transfer Learning

- In both settings: generally impractical to access prior tasks (unlike multi-task learning)
- Transfer learning: while training on source task, we don't really care about future task!
- Meta-learning: explicitly optimize for transferability!

Meta-Learning VS. Transfer Learning: a Case Study

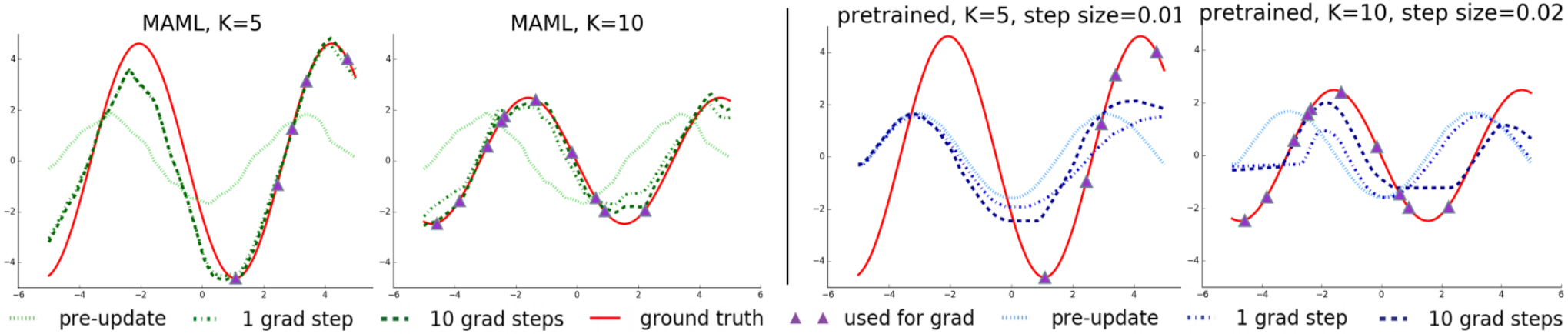
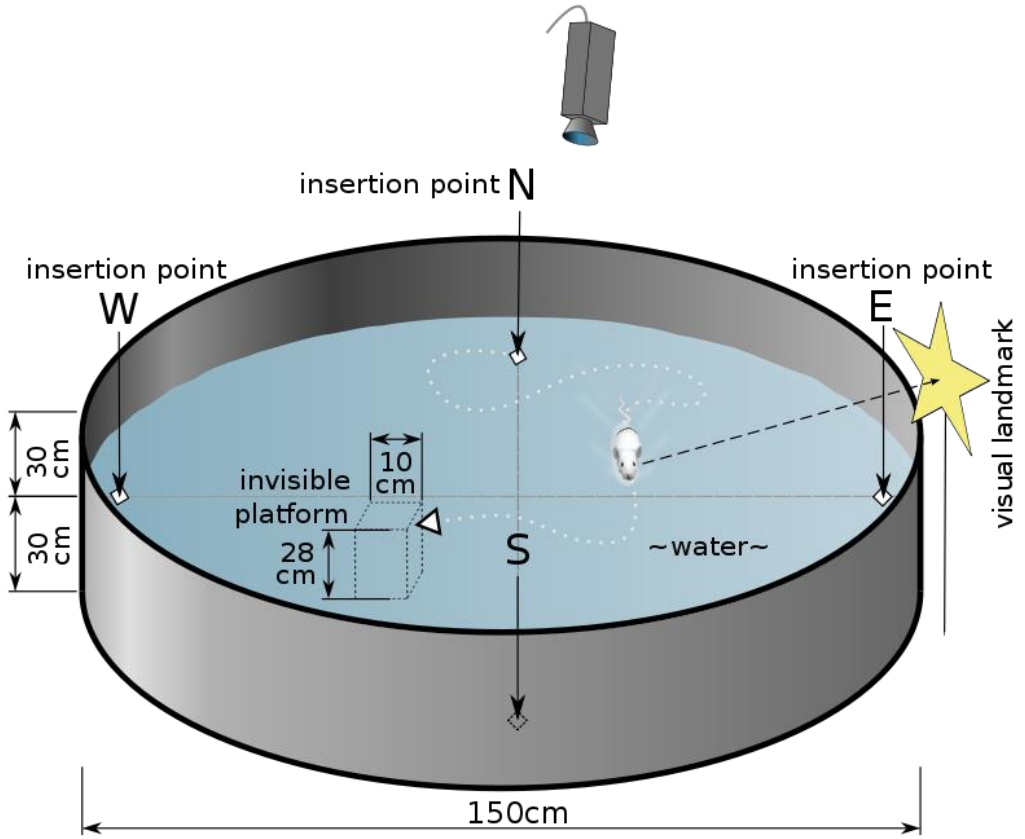


Figure 2. Few-shot adaptation for the simple regression task. Left: Note that MAML is able to estimate parts of the curve where there are no datapoints, indicating that the model has learned about the periodic structure of sine waves. Right: Fine-tuning of a model pretrained on the same distribution of tasks without MAML, with a tuned step size. Due to the often contradictory outputs on the pre-training tasks, this model is unable to recover a suitable representation and fails to extrapolate from the small number of test-time samples.

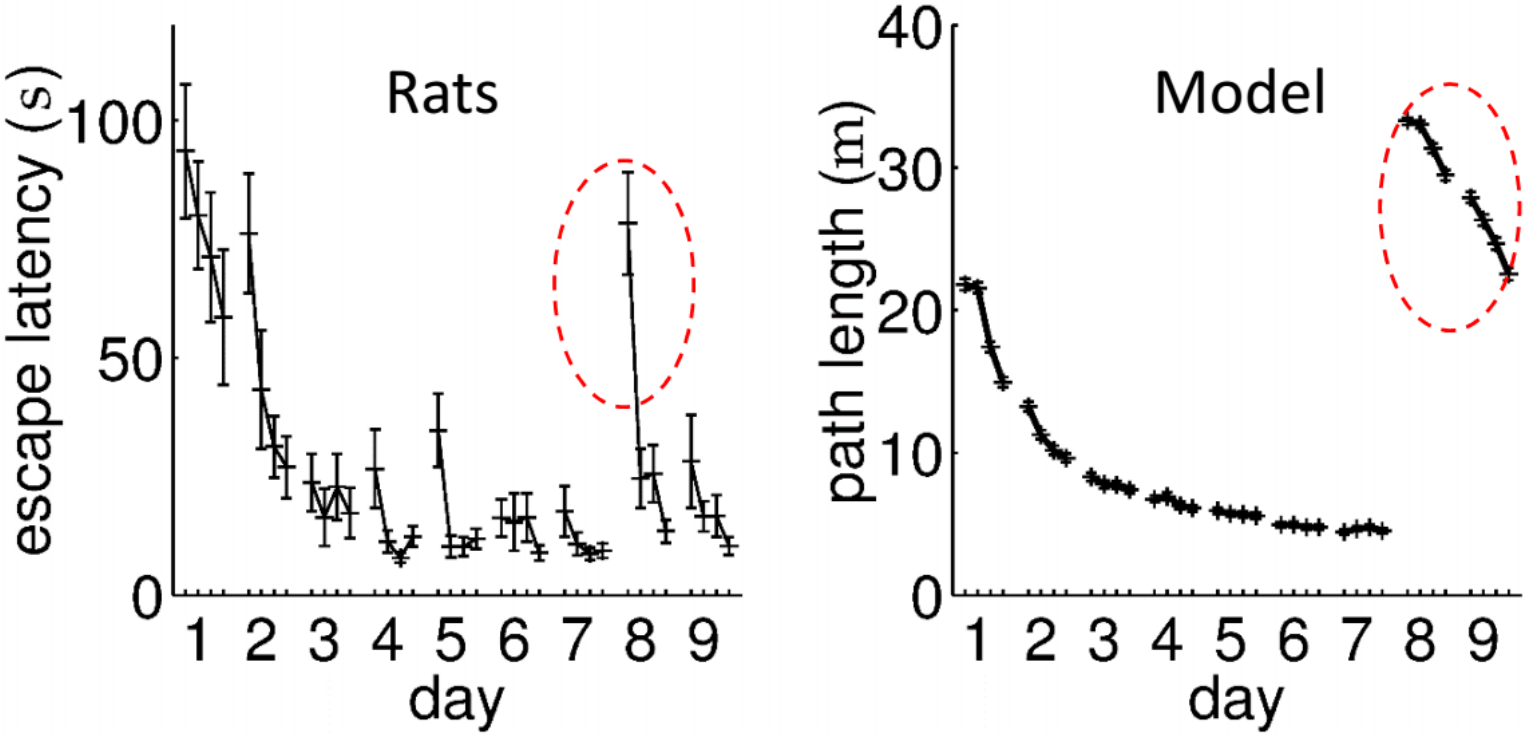
[Finn, et. Al. "Model-Agnostic Meta-Learning for Fast Adaptation of Deep Networks". ICML 2017]

Meta-Learning VS. Transfer Learning: a Behavioral Case Study



[http://www.scholarpedia.org/article/Morris_water_maze]

Meta-Learning VS. Transfer Learning: a Behavioral Case Study



[Bast, et. Al. “From Rapid Place Learning to Behavioral Performance: A Key Role for the Intermediate Hippocampus”. PLoS Biology]

Meta-Learning (Few-Shot Learning) Terminology

4-shot, 2-way problem: