

# Meta Reinforcement Learning

## Definition of Meta-RL<sup>1</sup>

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<sup>1</sup>Based on a blog by Lilian Weng

- Definition of MDP  $(S, A, P, R, \gamma)$ 
  - ▶  $S$  is a (finite) set of Markov states  $s \in S$
  - ▶  $A$  is a (finite) set of actions  $a \in A$
  - ▶  $P$  is dynamics/transition model for each action, that specifies  $P(s_{t+1} = s' \mid s_t = s, a_t = a)$
  - ▶  $R$  is a reward function  $R(s_t = s, a_t = a) = \mathbb{E}[r_t \mid s_t = s, a_t = a]$ 
    - ★ Sometimes  $R$  is also defined based on  $(s)$  or on  $(s, a, s')$
  - ▶ Discount factor  $\gamma \in [0, 1]$
- Task: Compute the optimal policy

$$\pi^*(s) \in \arg \max_{\pi} V^{\pi}(s)$$

# Meta-RL Problem Setting

- No single formal problem setting
- Usually based on a set of different MDPs  $\mathcal{M}$
- Commonalities in  $\mathcal{M}$  vary
- Often: shared state & action space
- Task: Compute optimal policy over all of  $\mathcal{M}$

# Example Setting 1: Two Walking agents

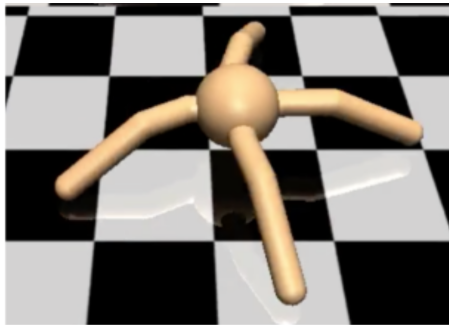
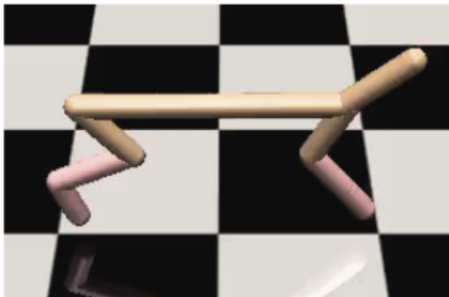


Figure: Two robots with different behavior.<sup>2</sup>

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<sup>2</sup>Image Source: MAML

## Example Setting 2: 100 Mazes



Figure: 100 Mazes, each with a different goal to reach.<sup>3</sup>

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<sup>3</sup>Image Source: VDS

## Example Setting 3: 200 Mazes



Figure: Mazes of two layouts and 100 goals each.<sup>4</sup>

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<sup>4</sup>Image Source: VDS

# Key Approaches in Meta-RL

- Meta-Learning Hyperparameters
  - ▶ Hyperparameter values for good performance
  - ▶ Alternative optimization methods
- Meta-Learning the Training Dynamics
  - ▶ Credit Assignment for state-action pairs
  - ▶ Problem-specific Exploration Strategies
- Task Generation
  - ▶ Task diversification for generalization
  - ▶ Curriculum Learning