



Learning Action Representations for Reinforcement Learning



Yash
Chandak



Georgios
Theocharous



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Scott
Jordan



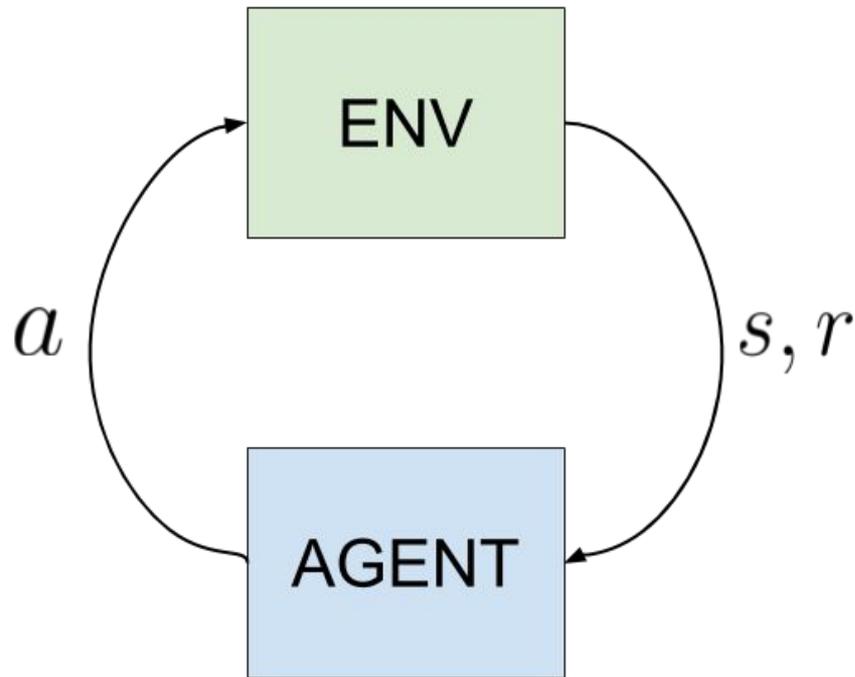
Philip
Thomas

Reinforcement Learning

s = State

a = Action

r = Reward



Problem Statement

Thousands of possible actions!

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- Personalized tutoring systems

The screenshot displays the Creative Cloud tutorials interface. At the top, there is a search bar labeled "Search Adobe Support" and a magnifying glass icon. Below the search bar, the page is organized into three main sections:

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 - "Create a business card" (8 min see how)
 - "Edit DSLR video" (51 min try)
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Try these projects first

- Edit your first photos (Try it, 12 min)
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- Option selection

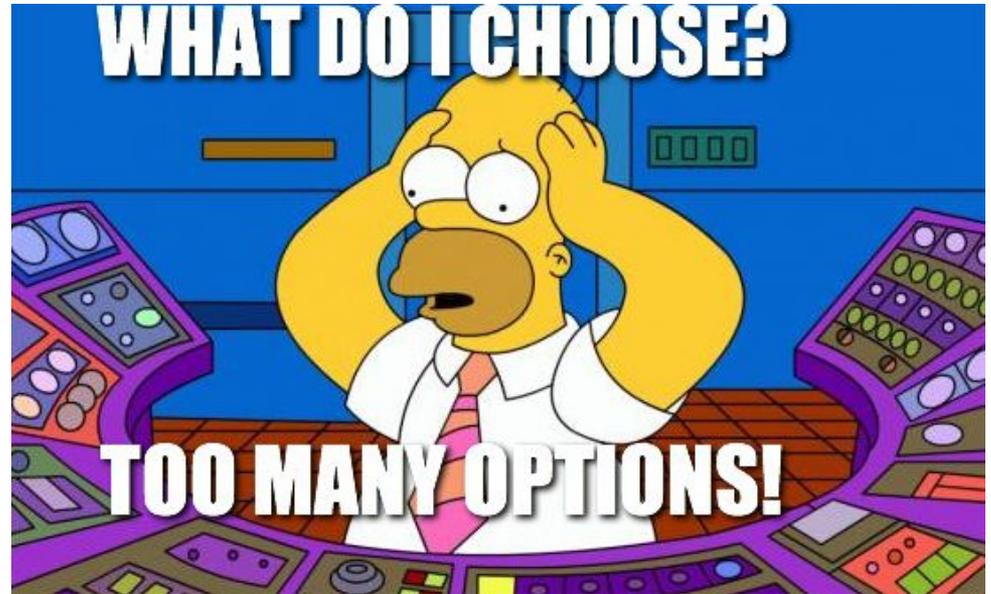
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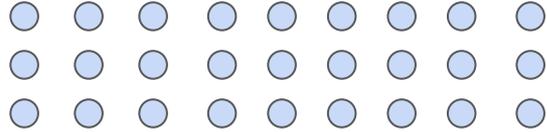
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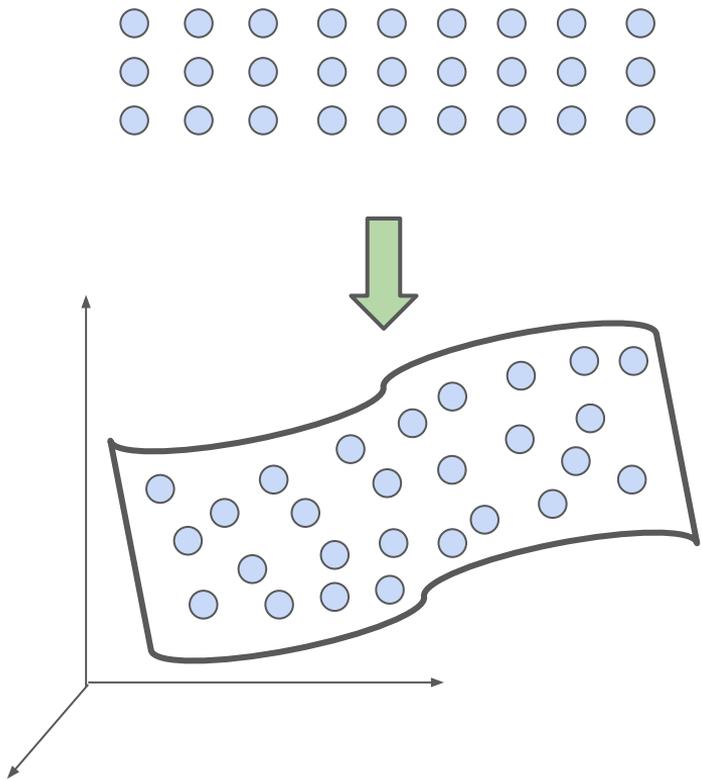


Key Insights



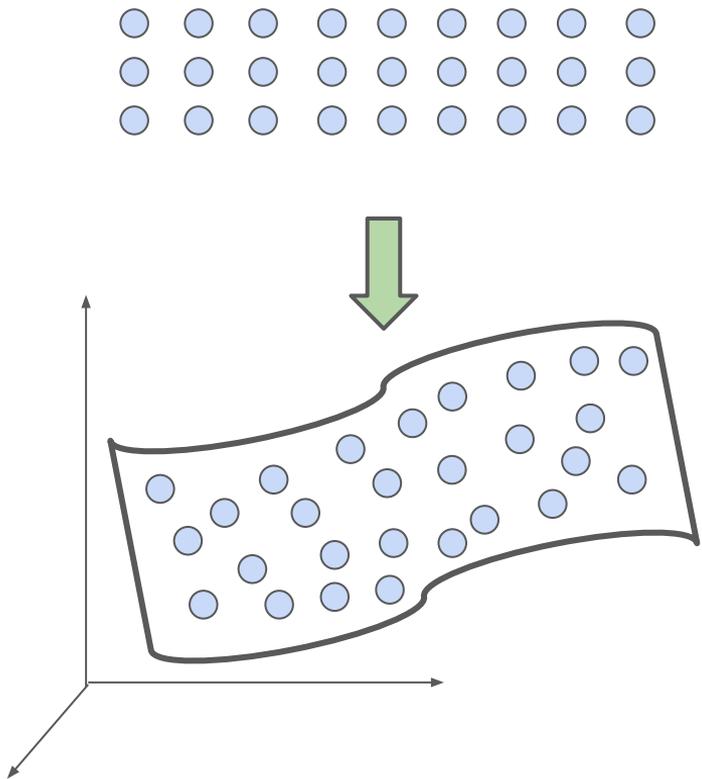
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Key Insights



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- There is a **low dimensional structure** underlying their behavior pattern.

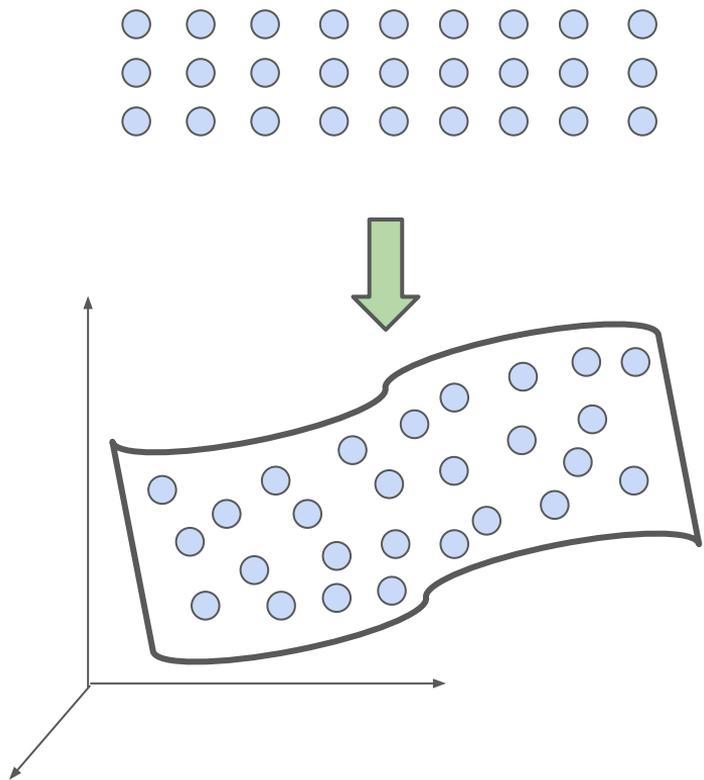
Key Insights



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- There is a **low dimensional structure** underlying their behavior pattern.
- This structure can be learned **independent of the reward**.



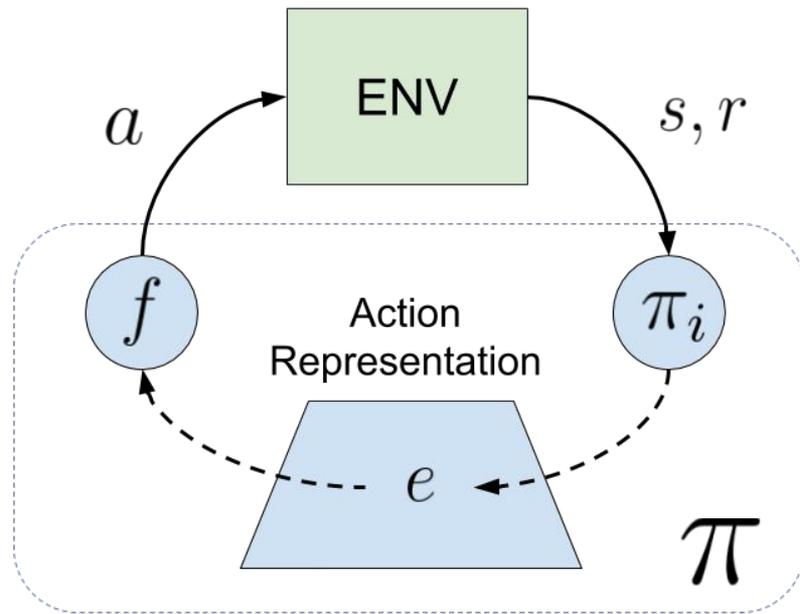
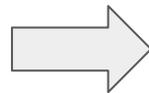
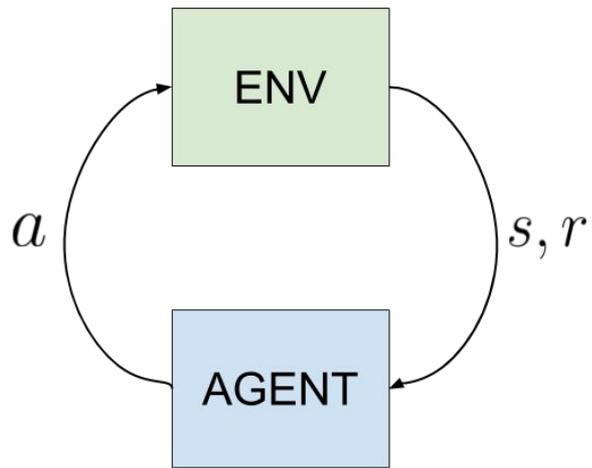
Key Insights



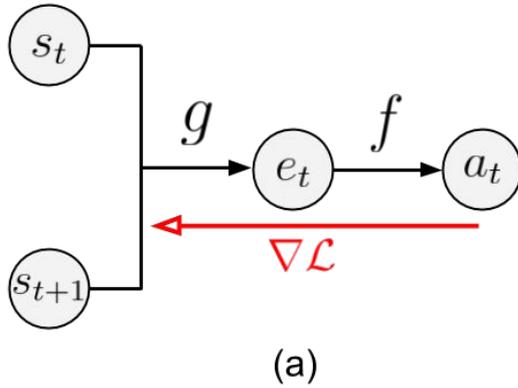
- Actions are **not independent** discrete quantities.
- There is a **low dimensional structure** underlying their behavior pattern.
- This structure can be learned **independent of the reward**.
- Instead of raw actions, agent can **act in this space of behavior** and **feedback can be generalized** to similar actions.



Proposed Method

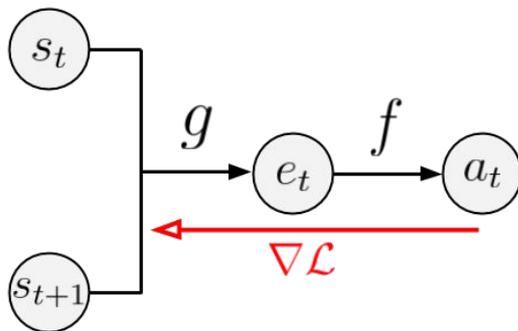


Algorithm

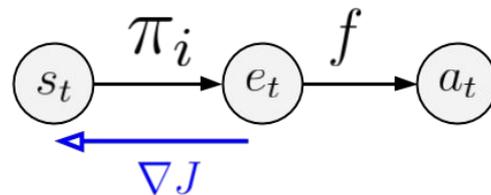


(a) Supervised learning of action representations.

Algorithm



(a)



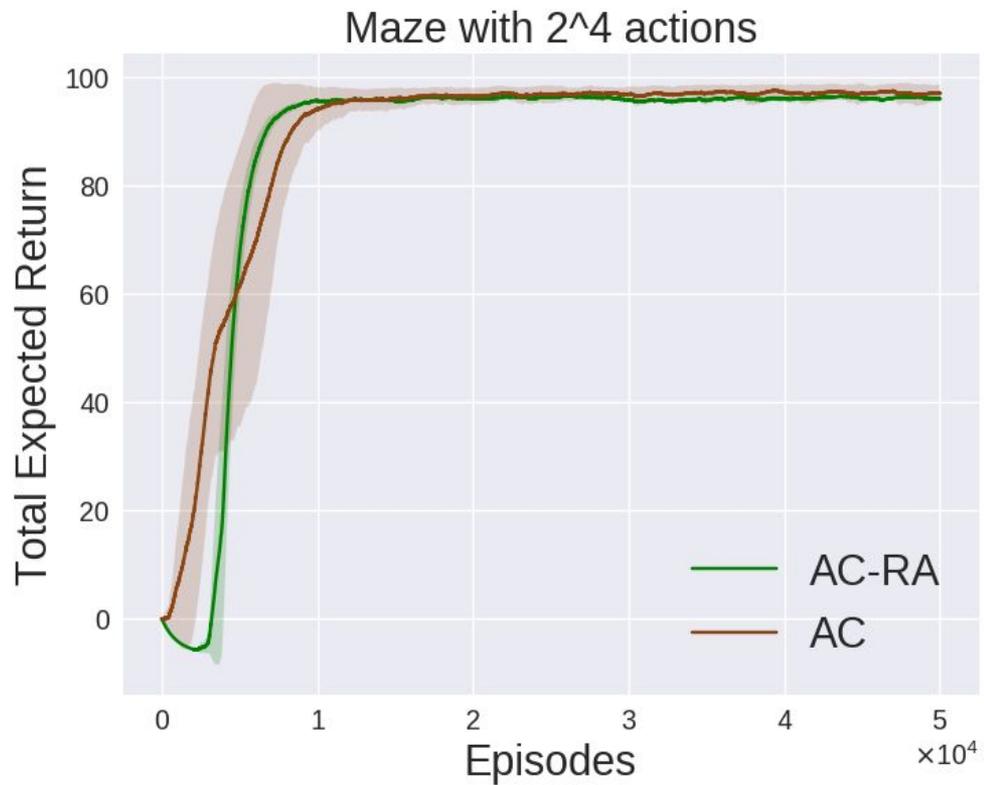
(b)

- (a) Supervised learning of action representations.
- (b) Learning internal policy with policy gradients.

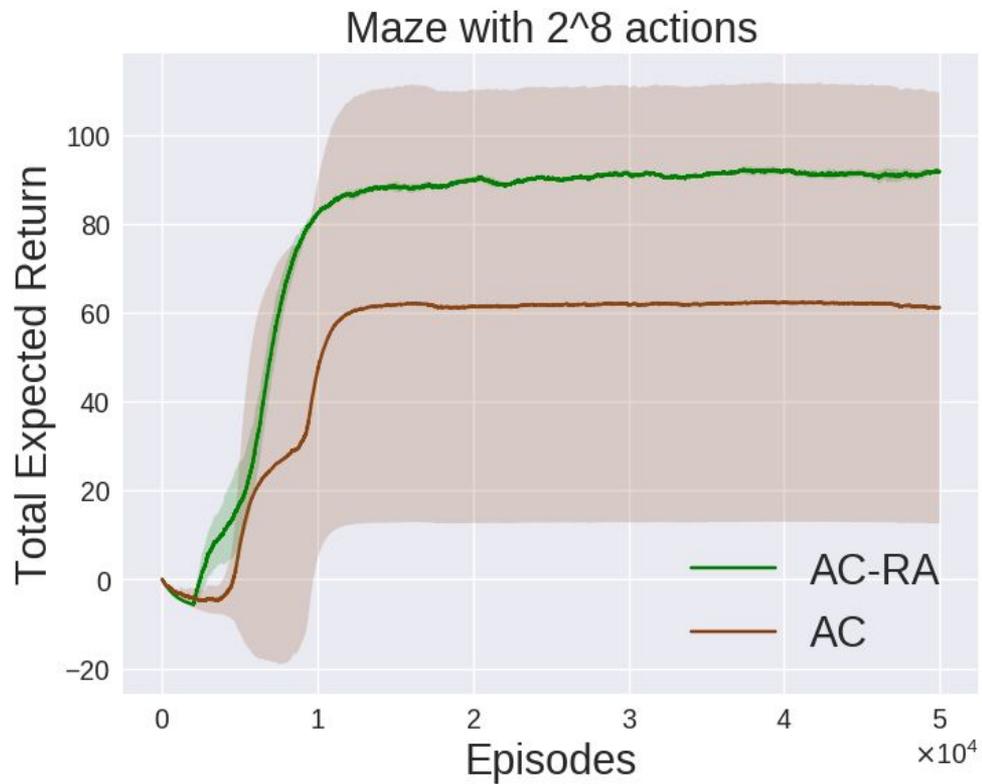
So, did it work?



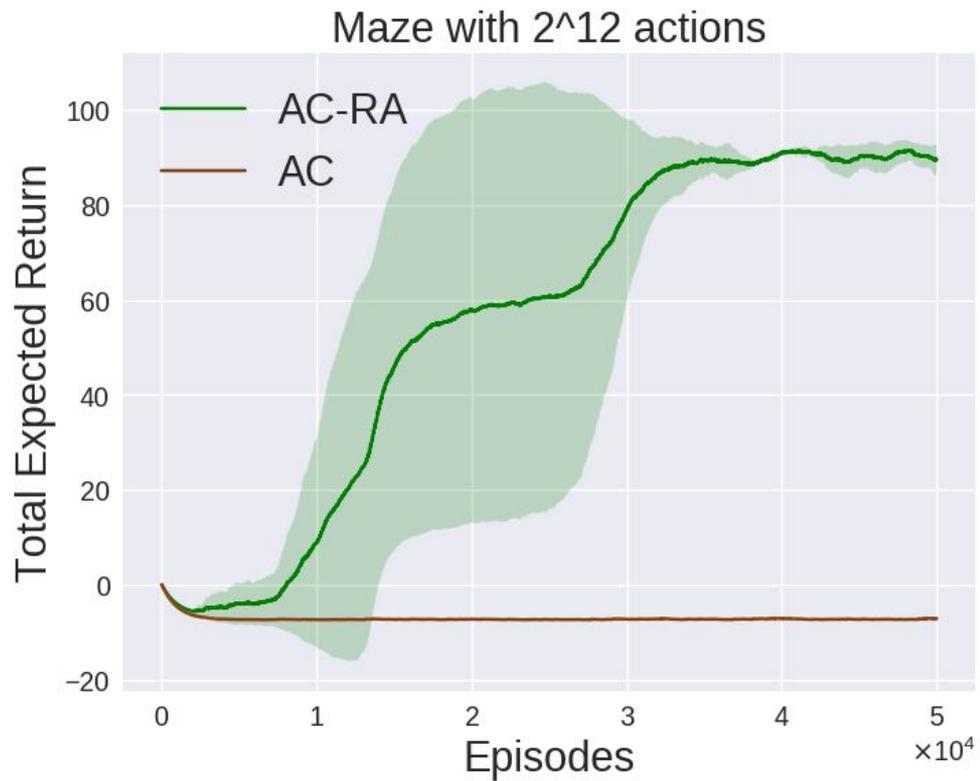
Results



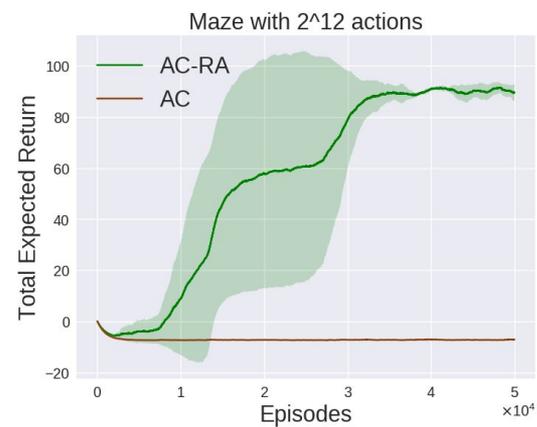
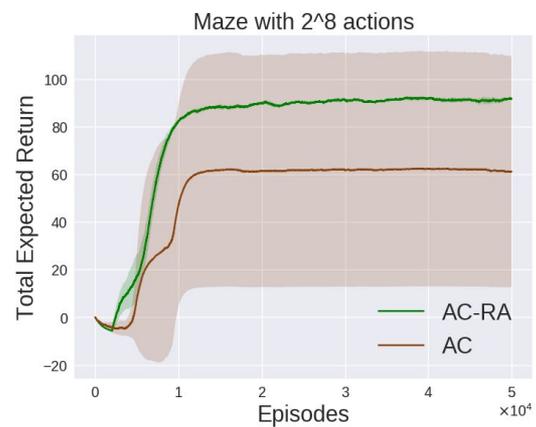
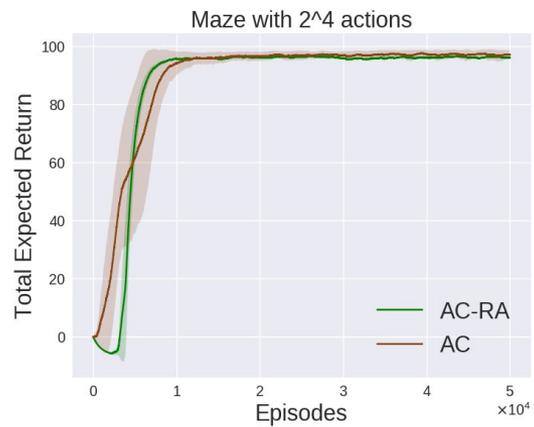
Results



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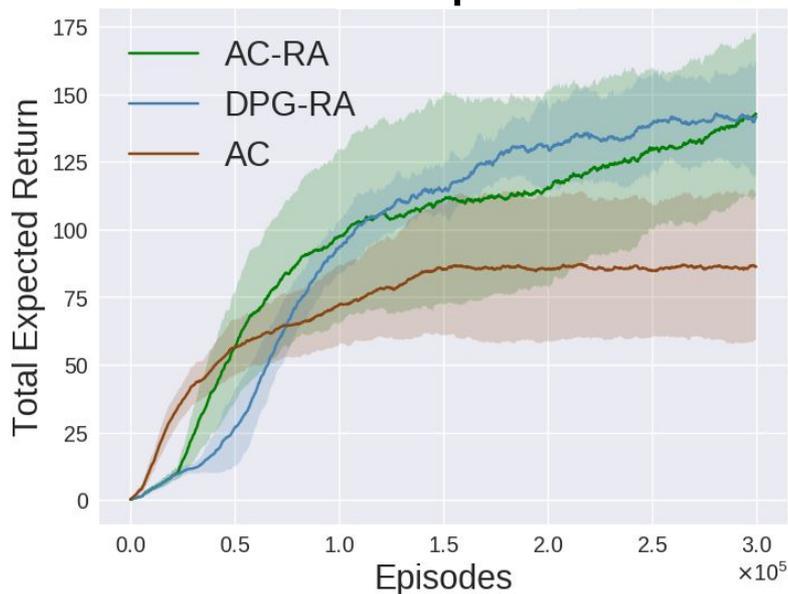


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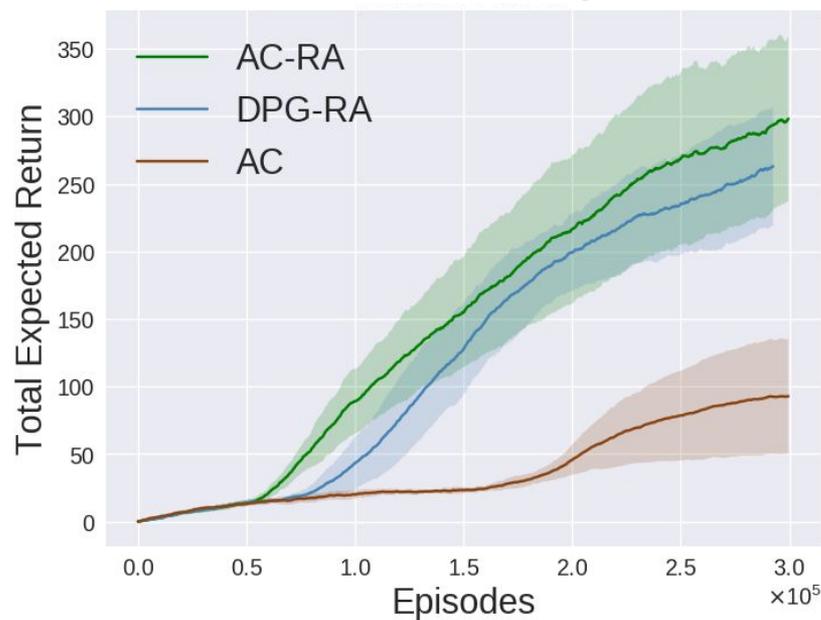
Real-world Applications at Adobe

HelpX



Actions = 1498 tutorials

Photoshop



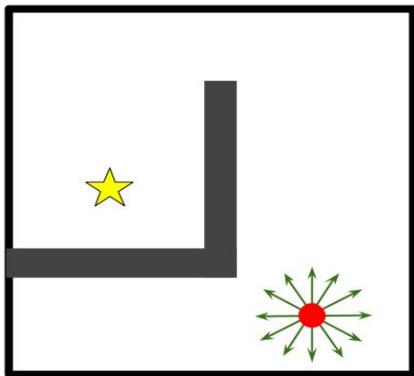
Actions = 1843 tools

Poster
#112
Today

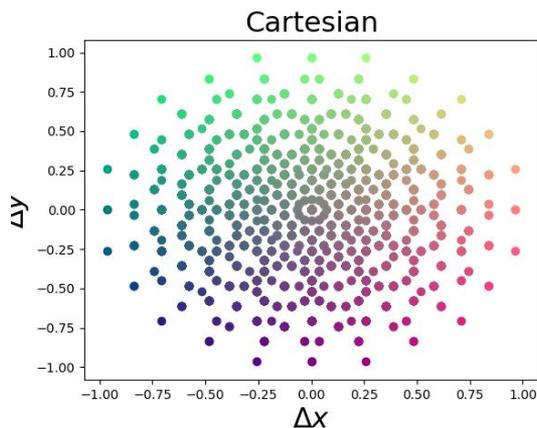


thank you!

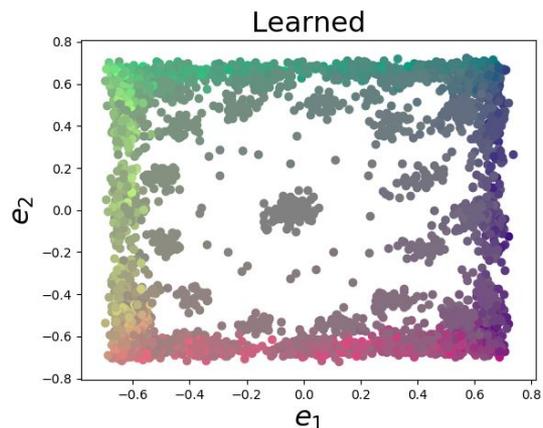
Results (Action representations)



Maze
domain



Actual behavior of 2^{12}
actions



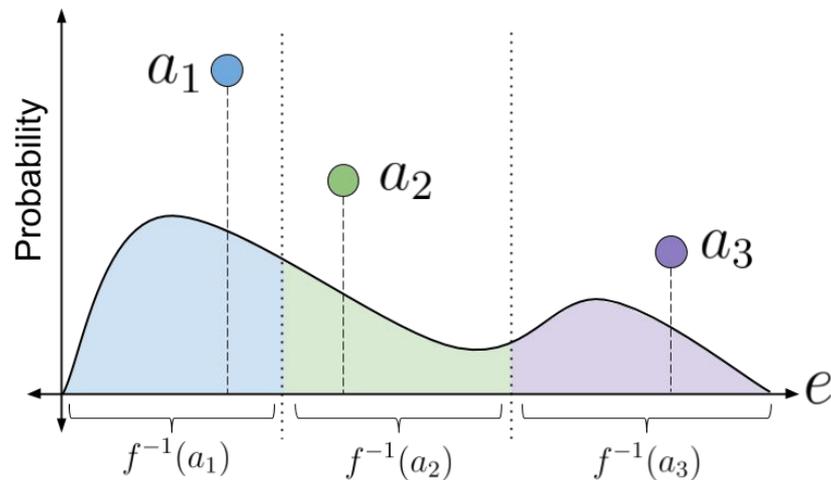
Learned representations of
 2^{12} actions

Policy decomposition

We can now consider a new overall policy, π_o , such that

$$\pi_o(a|s) = \int_{f^{-1}(a)} \pi_i(e|s) de.$$

Here, $\pi_i(e|s)$ represents a new internal policy which selects the action representation for the given state s .



Case 1: Action representations are known

- The internal policy acts in the space of action representations
- Any existing policy gradient algorithm can be used to improve its local performance, independent of the mapping function.

Property 1. For a deterministic function, f , that maps each point, $e \in \mathbb{R}^{d_e}$, in the representation space to an action, $a \in \{0, 1\}^{|\mathcal{A}|}$, the expected updates to θ based on $\nabla J_i(\theta)$ are equivalent to updates based on $\nabla J_o(\theta, f)$. That is,

$$\nabla J_o(\theta, f) = \nabla J_i(\theta).$$

Case 2: Learning action representations

- $P(a|e)$ required to map representation to action can be learned by satisfying the earlier assumption:

$$P(a|s, s') = \int_e P(a|e)P(e|s, s')$$

- We parameterize $P(a|e)$ and $P(e|s, s')$ with learnable functions f and g , respectively.
- Observed transition tuples are from the required distribution.
- Parameters can be learned by minimizing the stochastic KL divergence.
- Procedure is **independent of reward**.

Experiments

Toy Maze:

- Agent in continuous state with n actuators.
- 2^n actions. Exponentially large action space.
- Long horizon and single goal reward.

Adobe Datasets:

- N-gram based multi-time step user behavior model from passive data.
- Rewards defined using a surrogate objective.
- **Photoshop** tool recommendation (**1843** tools)
- **HelpX** tutorial recommendation (**1498** tutorials)

Advantages

- **Exploits structure** in space of actions.
- **Quick generalization of feedback** to similar actions.
- **Less parameters** updated using high variance policy gradients.
- **Drop-in extension** for existing policy gradient algorithms.