Knowledge Transfer through Value Function for Compositional Tasks

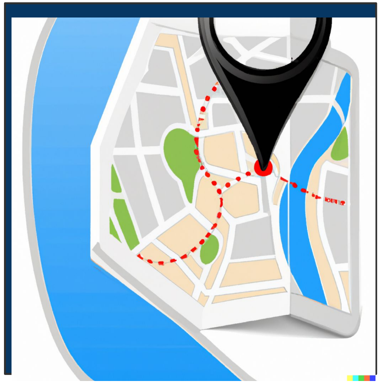
Henrique Donâncio, Matteo Leonetti, Laurent Vercouter

Motivation

Exploration is hard!

Sparse and binary outcomes

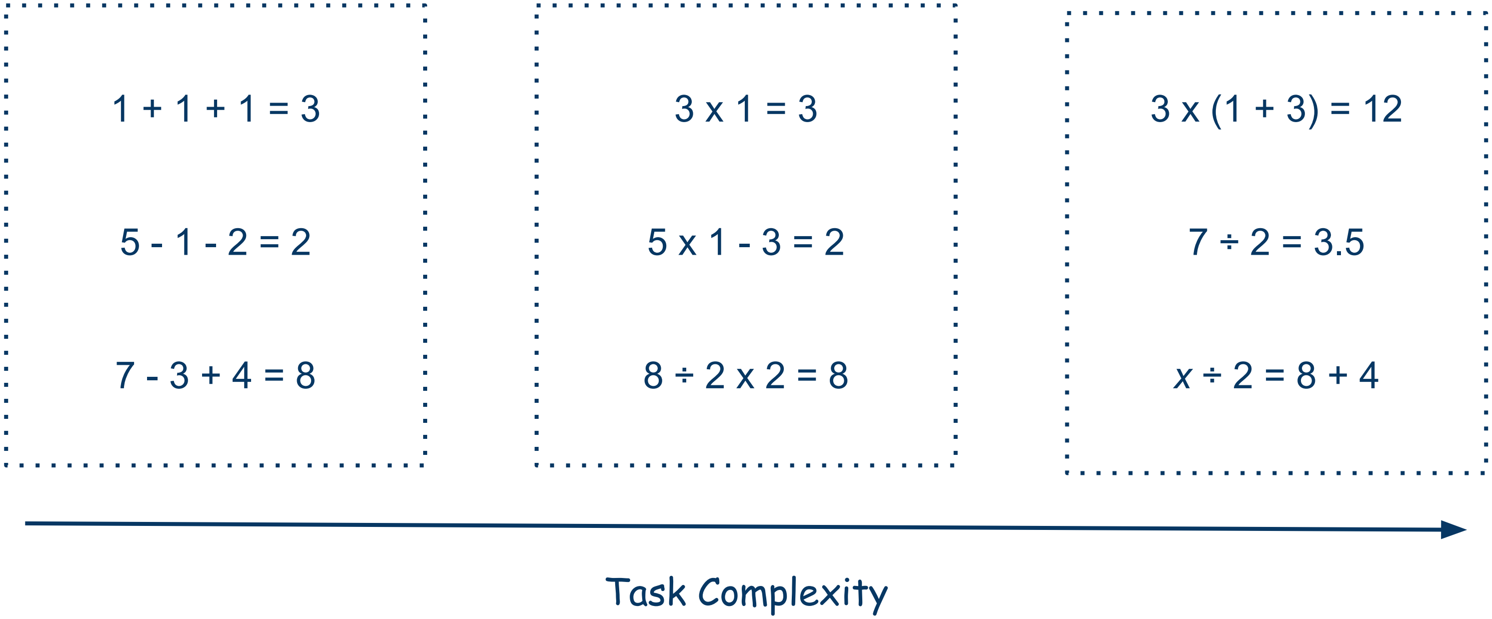
Multiple objectives



High-dimensional state spaces

All images are generated using Dalle 2 https://openai.com/dall-e-2

Curriculum Learning [Bengio et al. 2009]



1 + 1 + 1 = 3

5 - 1 - 2 = 2

7 - 3 + 4 = 8

3 x 1 = 3

5 x 1 - 3 = 2

8 ÷ 2 x 2 = 8

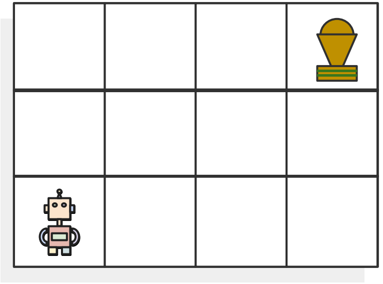
3 x (1 + 3) = 12

7 ÷ 2 = 3.5

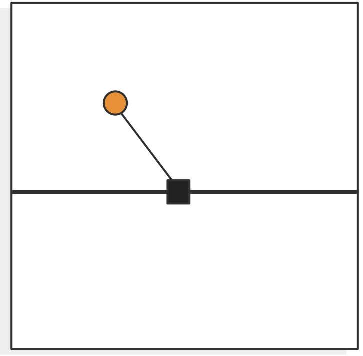
$x \div 2 = 8 + 4$

Task Complexity

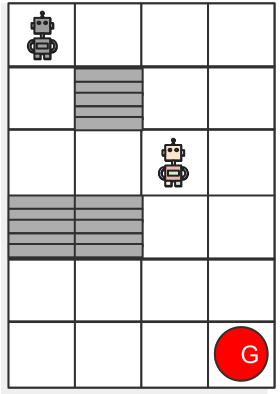
Making tasks easier: MDP degrees of freedom



Reward shaping *

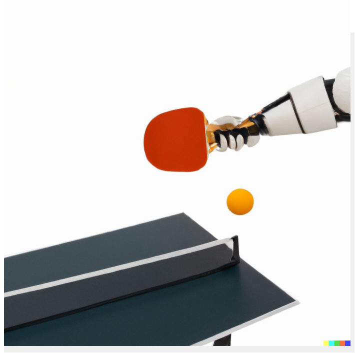


Transition probability

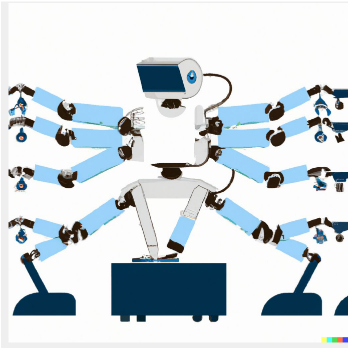


Initial state distribution

Making tasks easier: MDP degrees of freedom



States



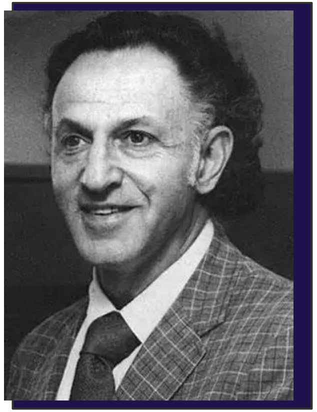
Actions

Knowledge Transfer for Compositional Representations

Q-Learning [Watkins & Dayan (1992)]

Q(s,a) How good is being in a state *s* and performing an action *a*?

$$Q(s,a) = Q(s,a) + \alpha[\overbrace{\underbrace{R(s,a) + \gamma max_{a'} Q(s',a')}_{\text{Target value}} -Q(s,a)}^{\text{TD error}}]$$



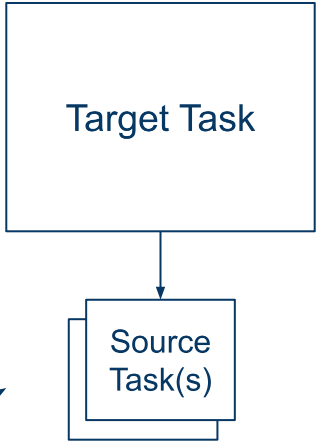
Richard Bellman

state

action

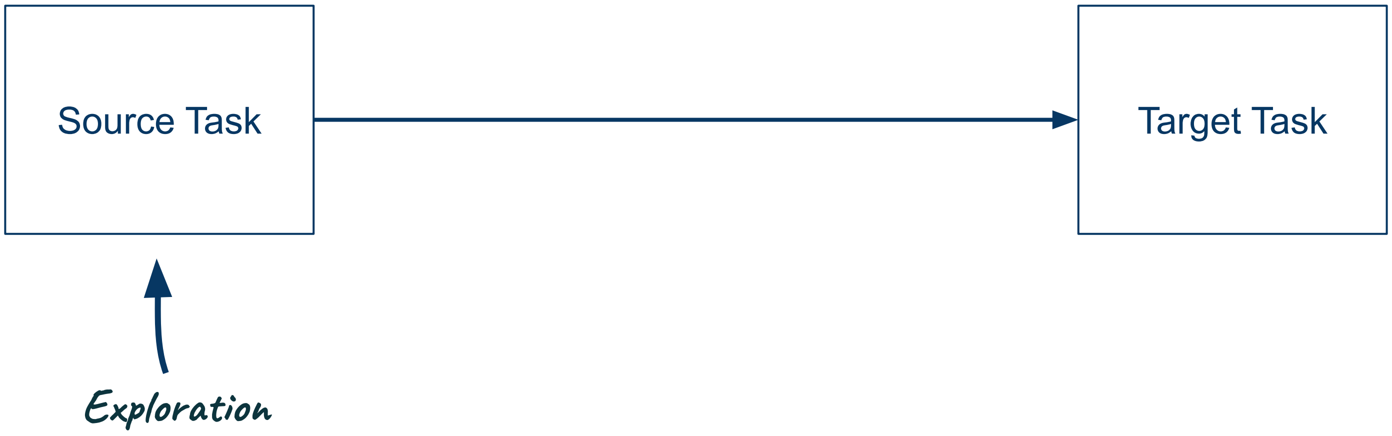
1.234	1.434	1.434	…
0.234	…		
…			

Knowledge Transfer for Compositional Representations

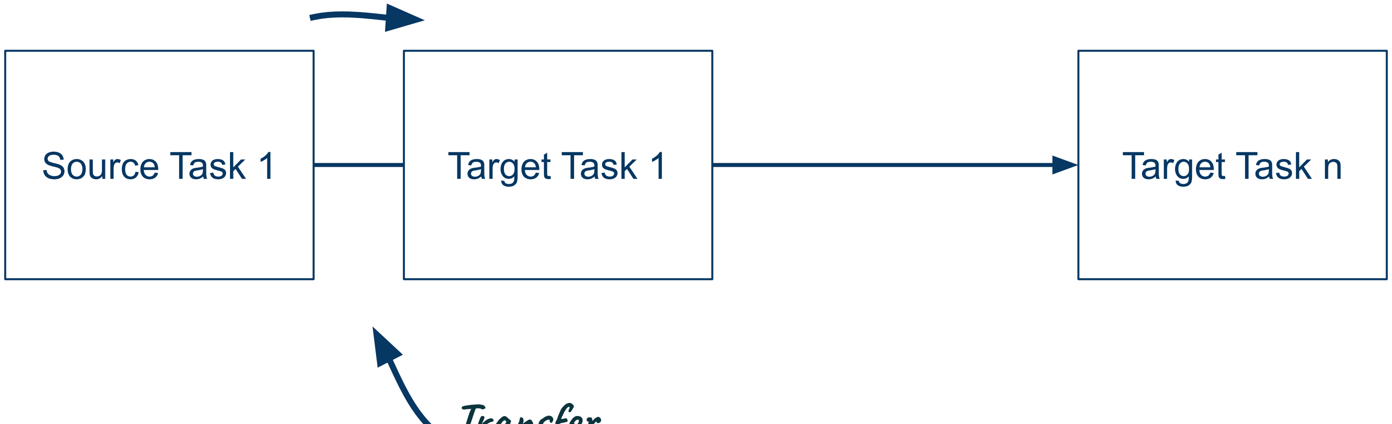


The curriculum is given!

Knowledge Transfer for Compositional Representations



Knowledge Transfer for Compositional Representations

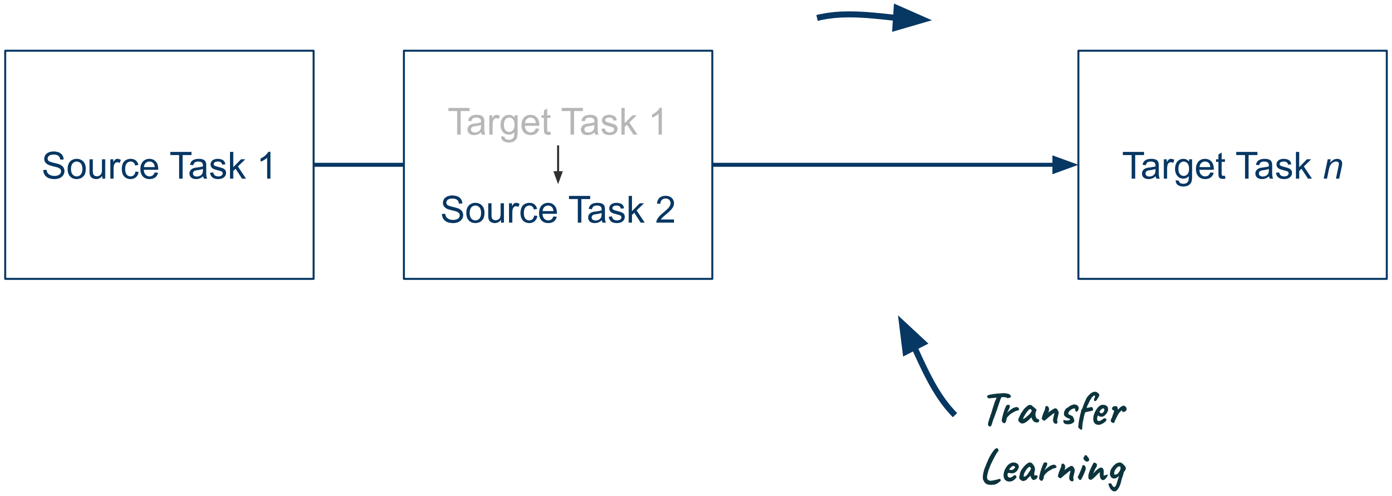


Transfer Learning

$$softmax(\{max(Q_s), max(Q_t)\})$$

$$a = \begin{cases} argmax(Q_s), softmax_{Q_s} \\ argmax(Q_t), softmax_{Q_t} \end{cases}$$

Knowledge Transfer for Compositional Representations



Source Task 1

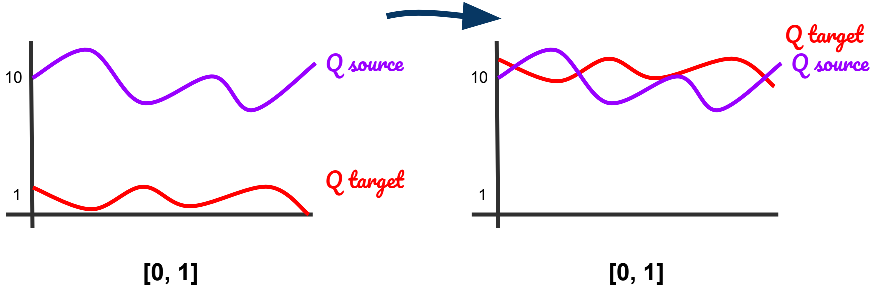
Target Task 1

Source Task 2

Target Task *n*

Transfer Learning

Knowledge Transfer for Compositional Representations

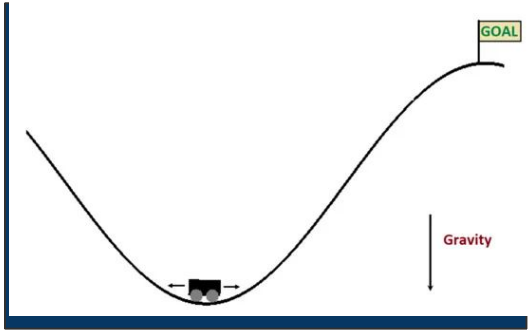


$$a = \overset{softmax(\{max(Q_s), max(Q_t)\})}{\begin{cases} argmax(Q_s), softmax_{Q_s} \\ argmax(Q_t), softmax_{Q_t} \end{cases}}$$

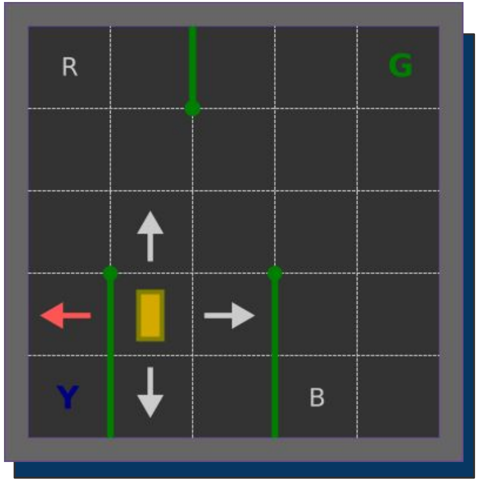
Allow target task policy play its own actions

Mitigate distributional shift

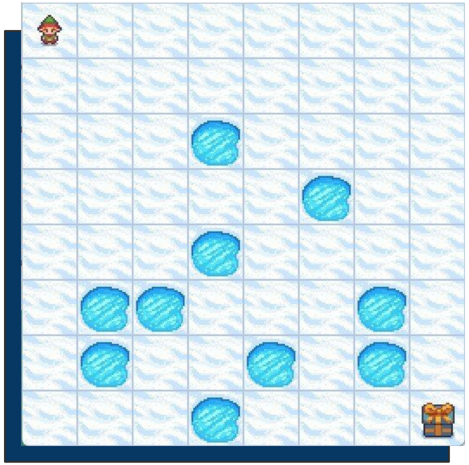
Proof-of-concept



Mountain Car

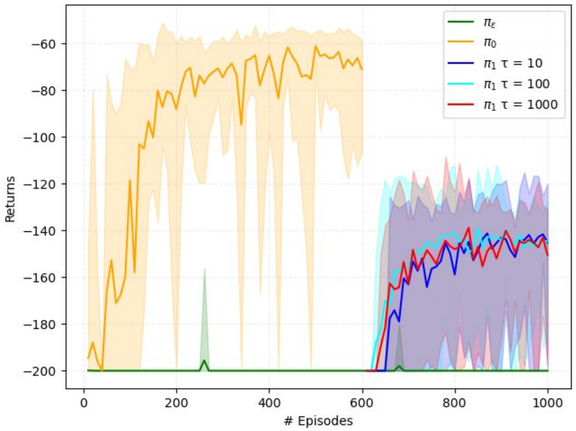


Taxi cab

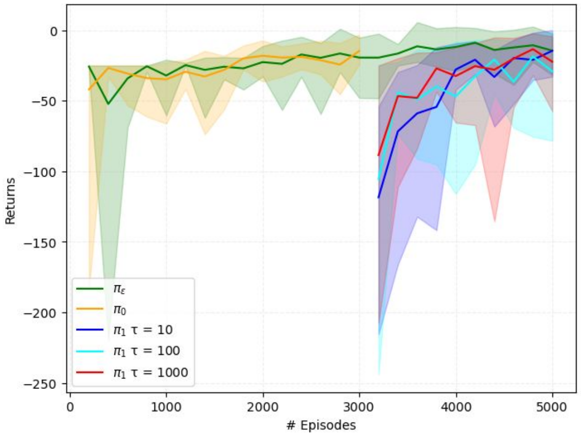


Frozen Lake

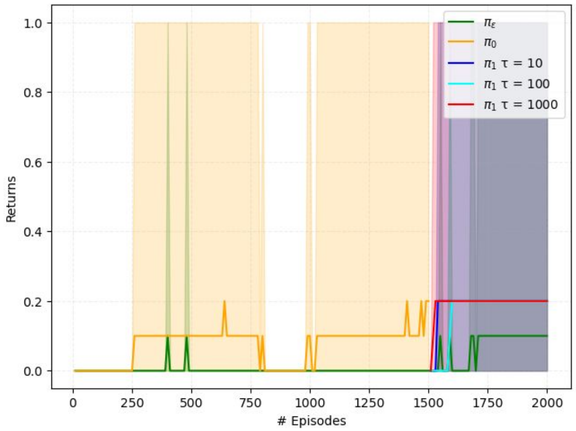
Results



Mountain Car



Taxi cab



Frozen Lake

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