Learning Reward Machines for Partially Observable Reinforcement Learning

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ELEMENT AI

KR 2020
September 16

Hi, I'm Rodrigo :)

Hi, I'm an AI researcher

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"The ultimate goal of AI is to create computer programs that can solve problems in the world as well as humans."

— John McCarthy

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Our research incorporates insights from **knowledge**, **reasoning**, and **learning**, in service of building general-purpose agents.

Reinforcement Learning (RL)

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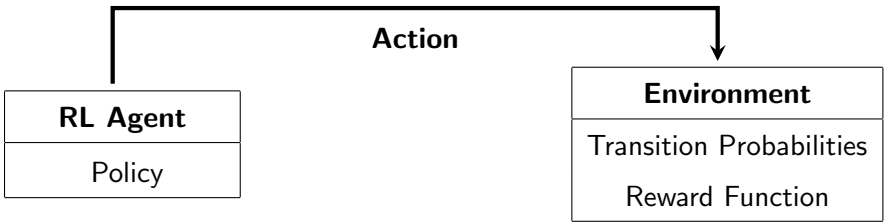

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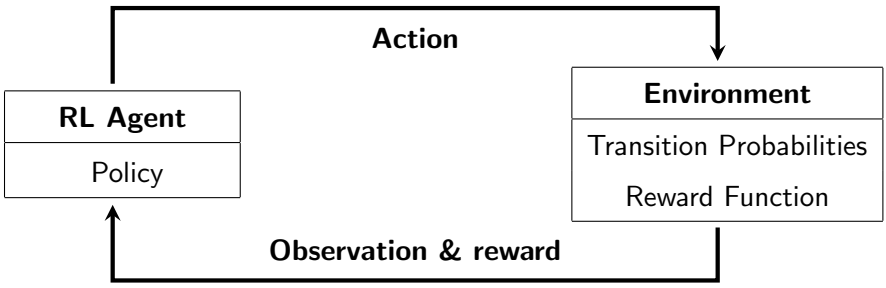

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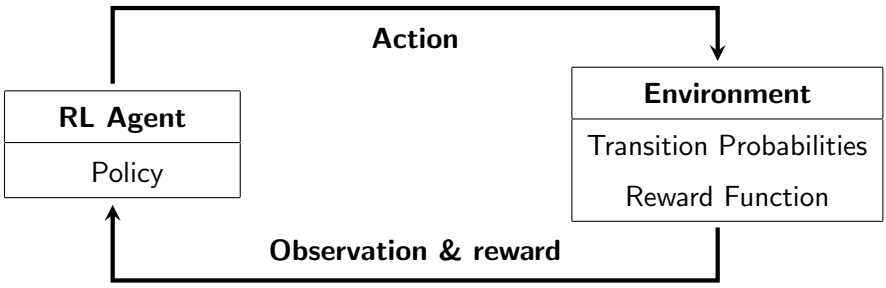
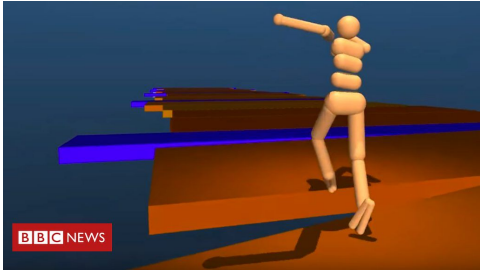


This learning process captures some aspects of human intelligence.

Reinforcement Learning (RL)



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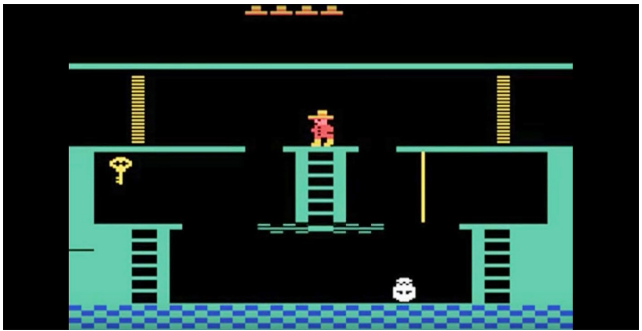

How to enhance RL with KR

Reinforcement Learning (RL)

Long-standing RL problems that we tackled using KR:

- Reward specification.
- Sample efficiency.
- Memory.
- ...

Reward specification

Reward speci cation

Make a bridge: get wood, iron, and use the factory

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Make a bridge: get wood, iron, and use the factory

LTL specifications[1]:

$3(\texttt{got\_wood} \wedge 3\texttt{used\_factory}) \wedge 3(\texttt{got\_iron} \wedge 3\texttt{used\_factory})$

[1] Teaching Multiple Tasks to an RL Agent using LTL (AAMAS-18).

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Reward machines[2]:
Automata-based reward functions

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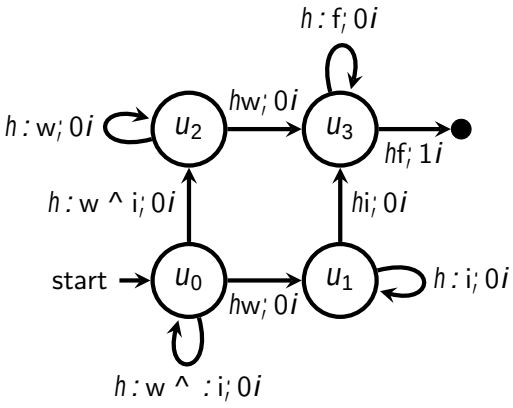
[2] Using Reward Machines for High-Level Task Speci cation and Decomposition in RL (ICML-18).

Reward machine



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Formal languages[3]:
Many formal languages *!* Reward machines.

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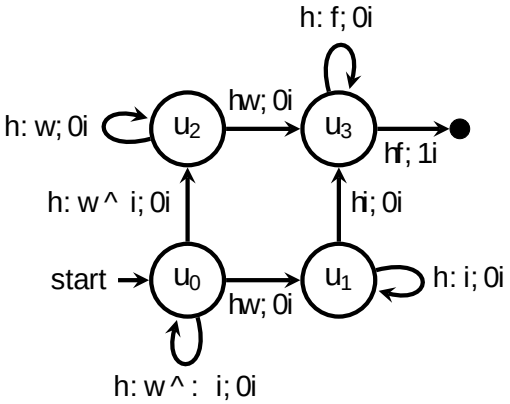
[3] LTL and Beyond: Formal Languages for Reward Function Speci cation in RL (IJCAI-19).

Sample efficiency

Sample e ciency

Reward machine



How to exploit the reward machine's structure:

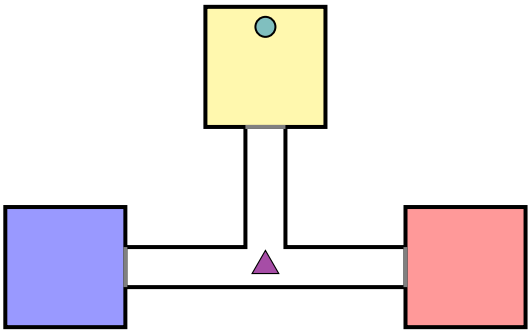
- CRM : Counterfactual reasoning.
- HRM : Task decomposition.
- RS: Reward shaping.

Sample e ciency

Sample e ciency

Memory

Memory



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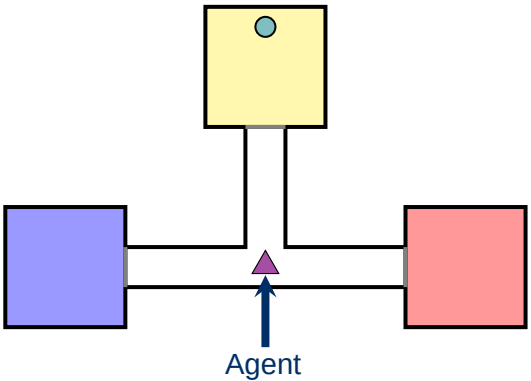

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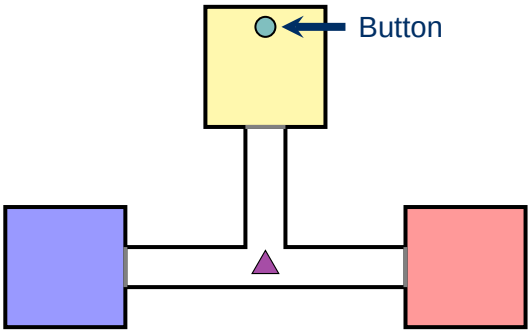

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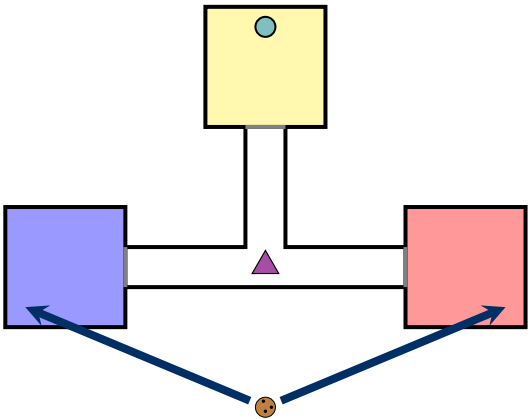
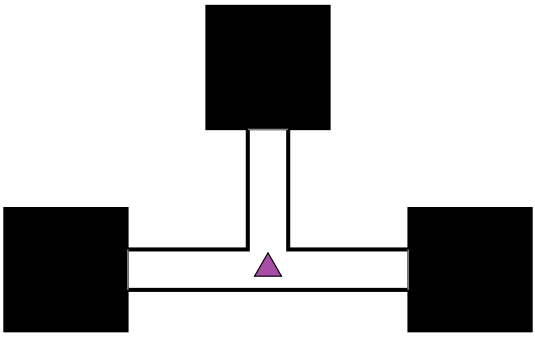


(Cookie)

Memory



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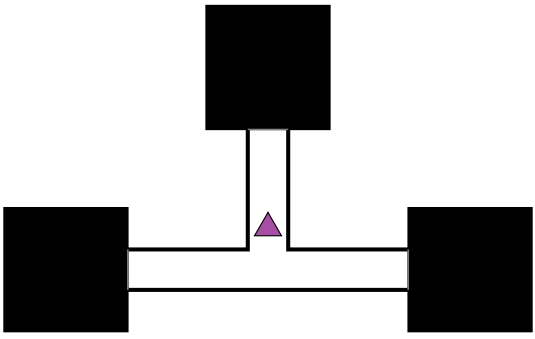

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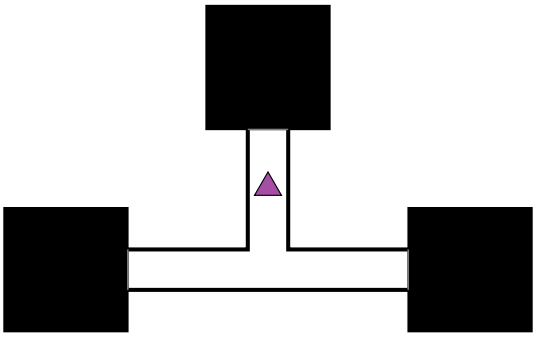

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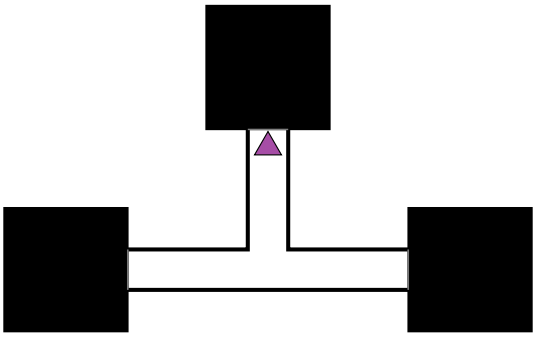

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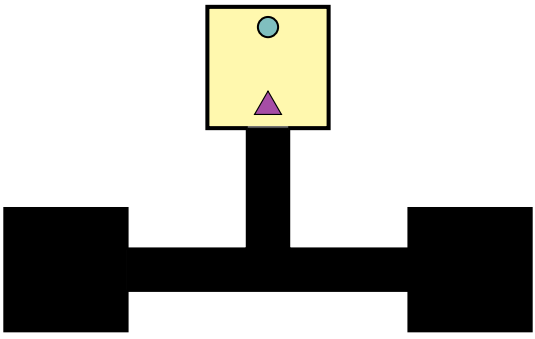

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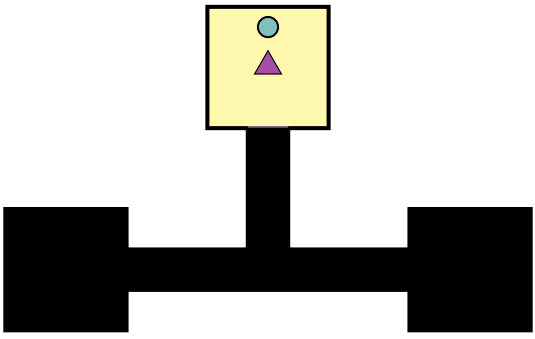

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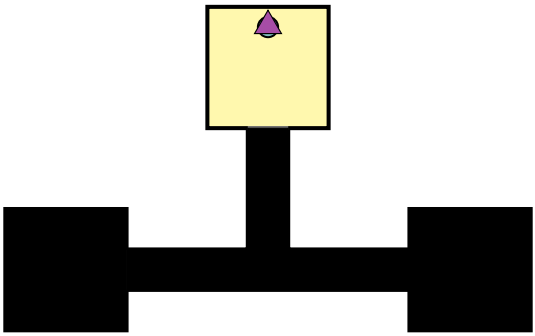

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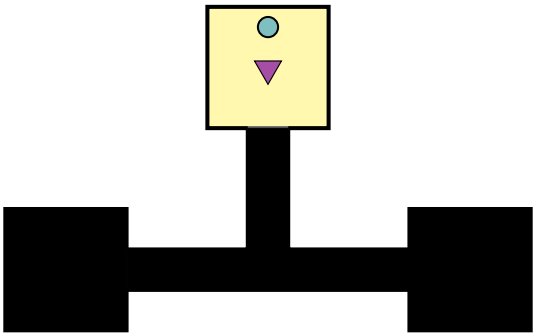

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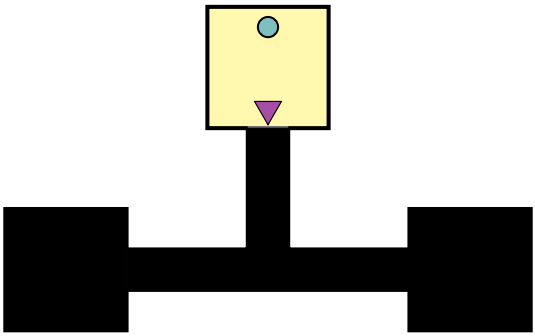

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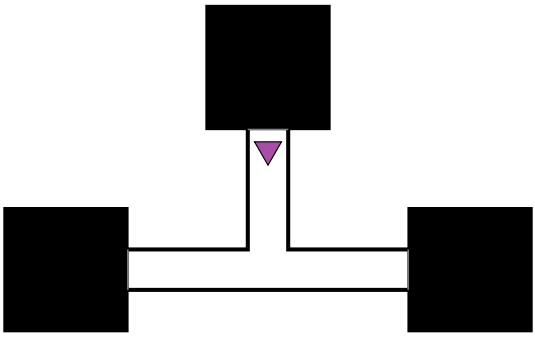

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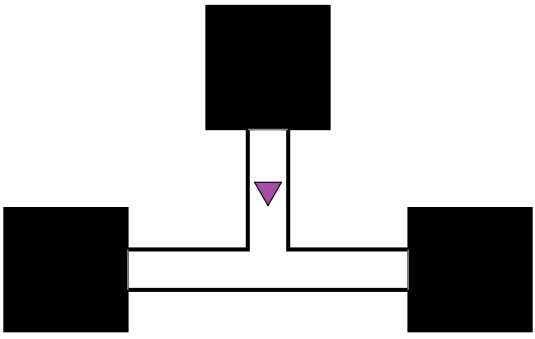

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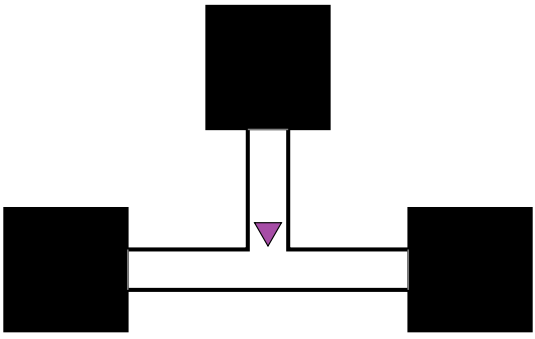

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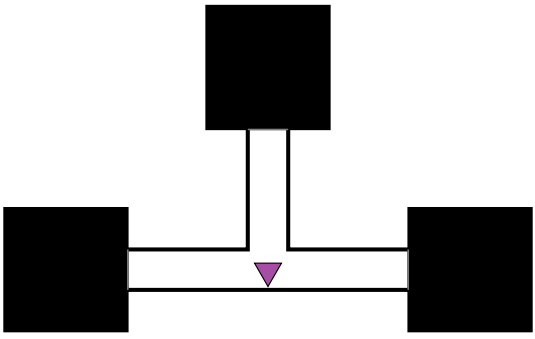

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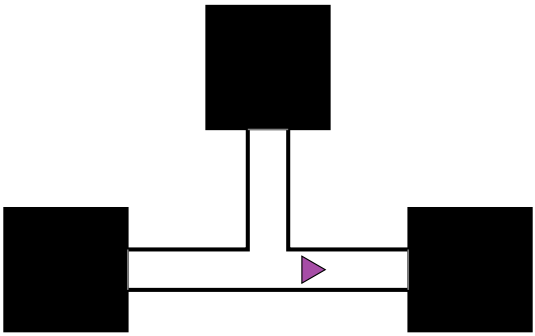

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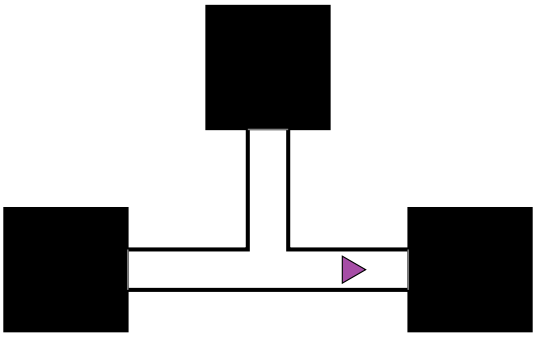

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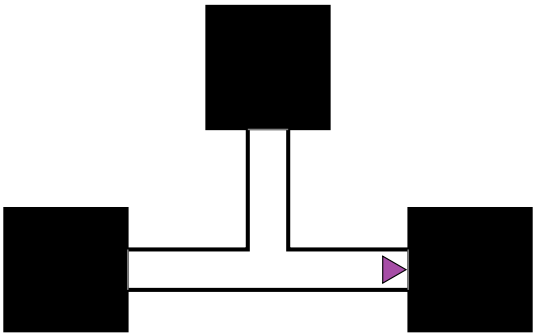

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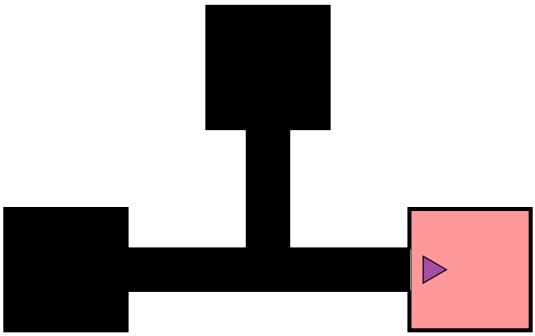

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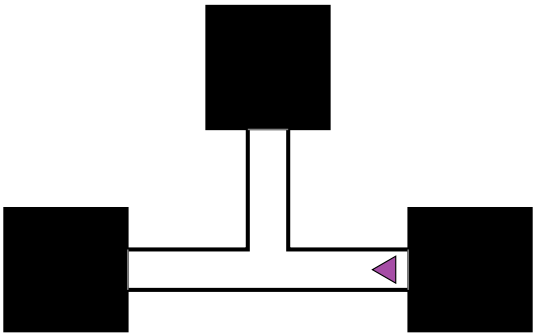

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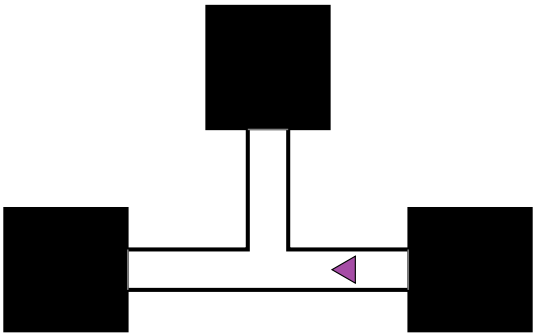

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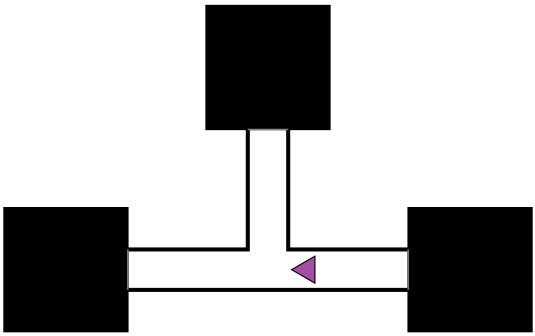

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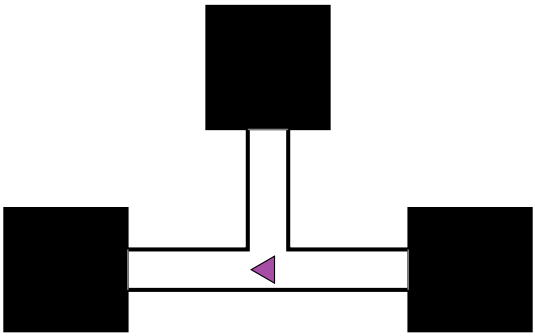

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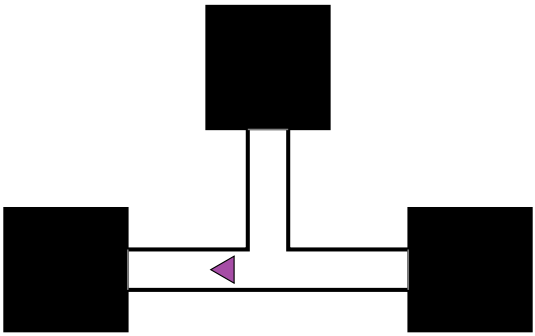

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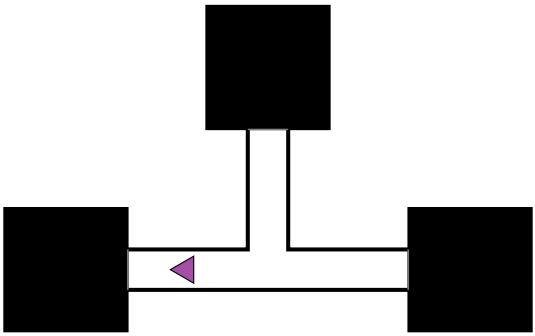

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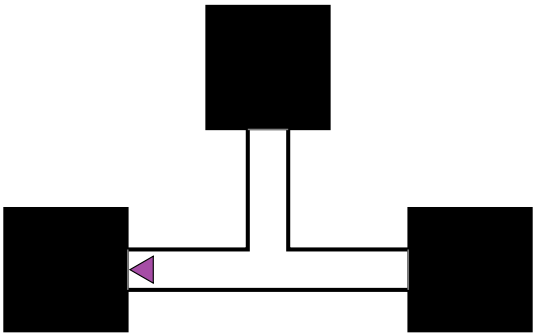

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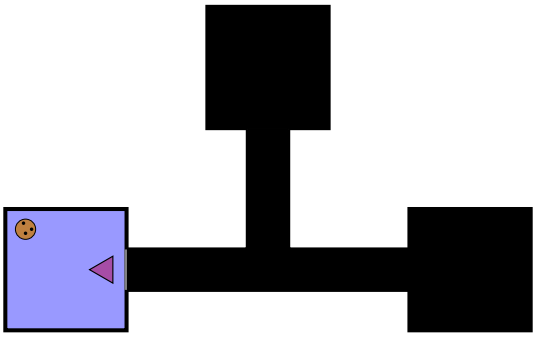

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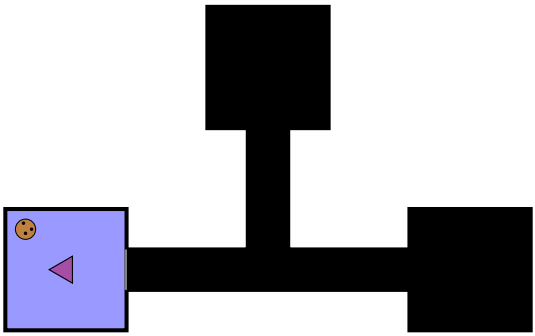

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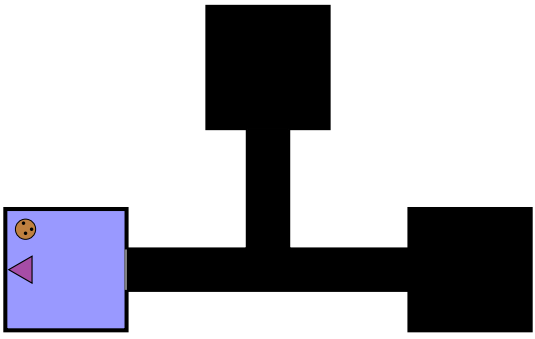

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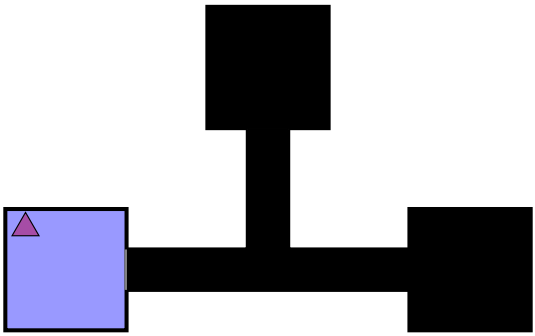
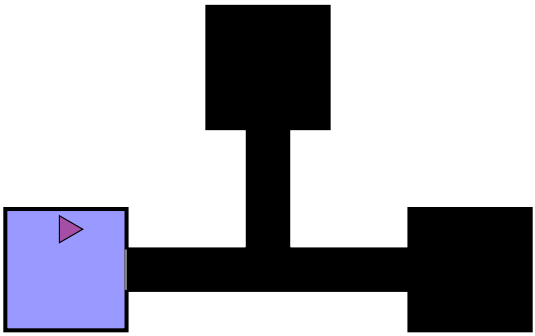


(+1 Reward)

Memory



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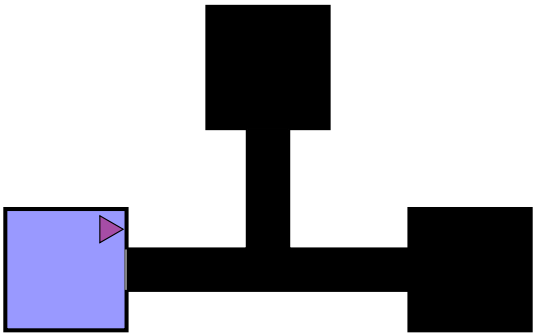

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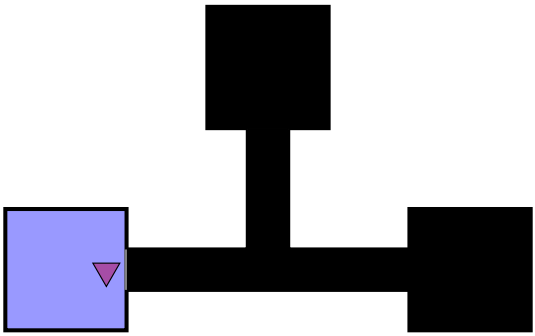

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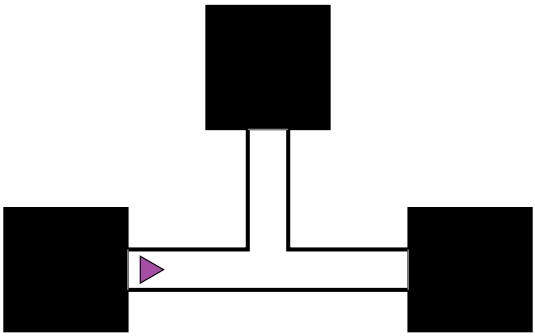

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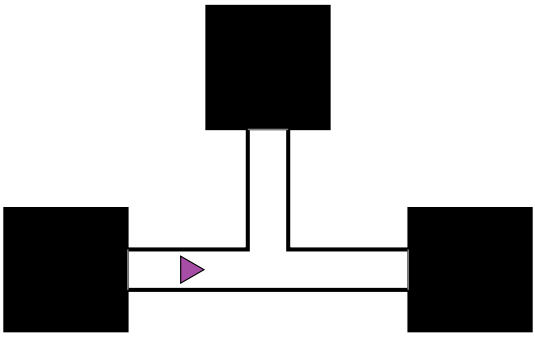

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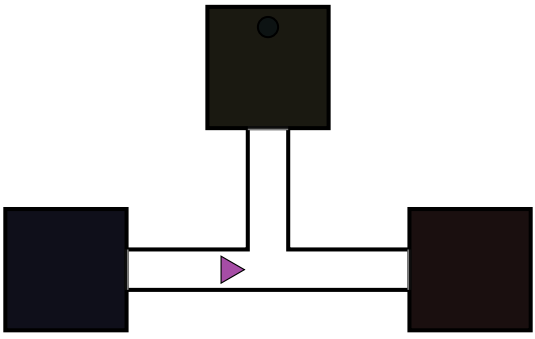

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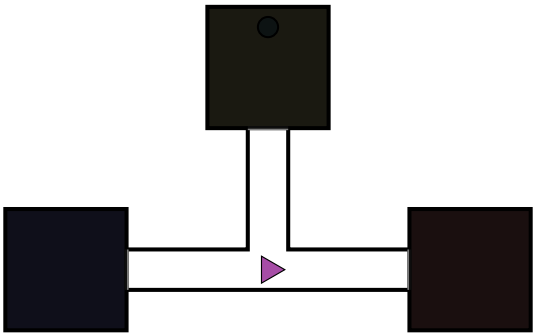
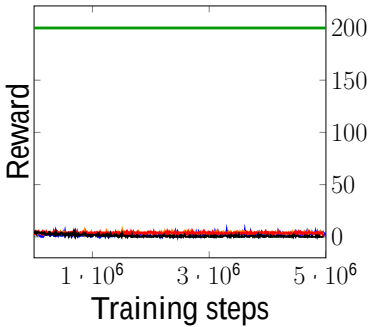


Memory

The most popular approach:

Training LSTMs policies using a policy gradient method.

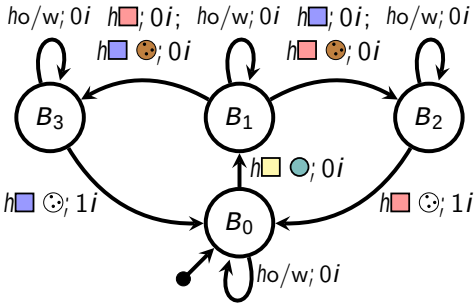
... starves in the cookie domain.



Legend:
- Optimal
- ACER
- A3C
- PPO
- DDQN

Reward Machines as memory

If the agent can detect the color of the rooms (■; □; ■; □), and when it presses the button (●), eats a cookie (🍪), and sees a cookie (🍪), then:



... becomes a **"perfect" memory** for the cookie domain.

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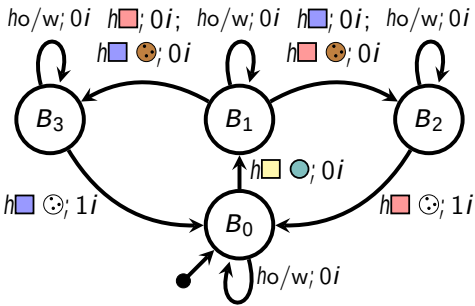

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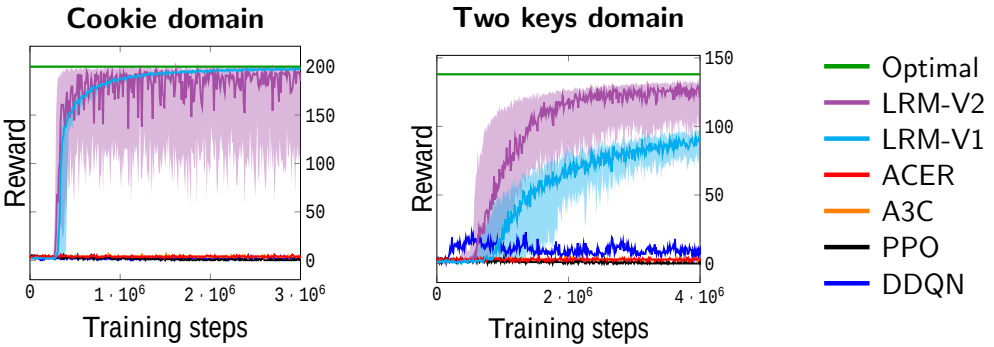
Memory



*__Note__: The detectors were also given to the baselines.

Summary

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If you are interested in KR \ RL, consider reading our papers:

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Symbolic Plans as High-Level Instructions for Reinforcement Learning (ICAPS-20)

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Code: `https://bitbucket.org/RToroIcarte/`

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Teaching Multiple Tasks to an RL Agent using LTL (AAMAS-18)
Using Reward Machines for High-Level Task Specification and Decomposition in RL (ICML-18)
LTL and Beyond: Formal Languages for Reward Function Specification in RL (IJCAI-19)
Learning Reward Machines for Partially Observable RL (NeurIPS-19)
Symbolic Plans as High-Level Instructions for Reinforcement Learning (ICAPS-20)

Code: `https://bitbucket.org/RToroIcarte/`

Thanks! :)