RePReL

Integrating Relational Planning and Reinforcement Learning for Effective Abstraction

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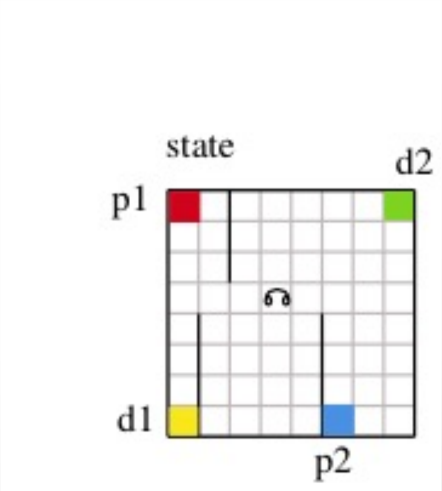
Overview

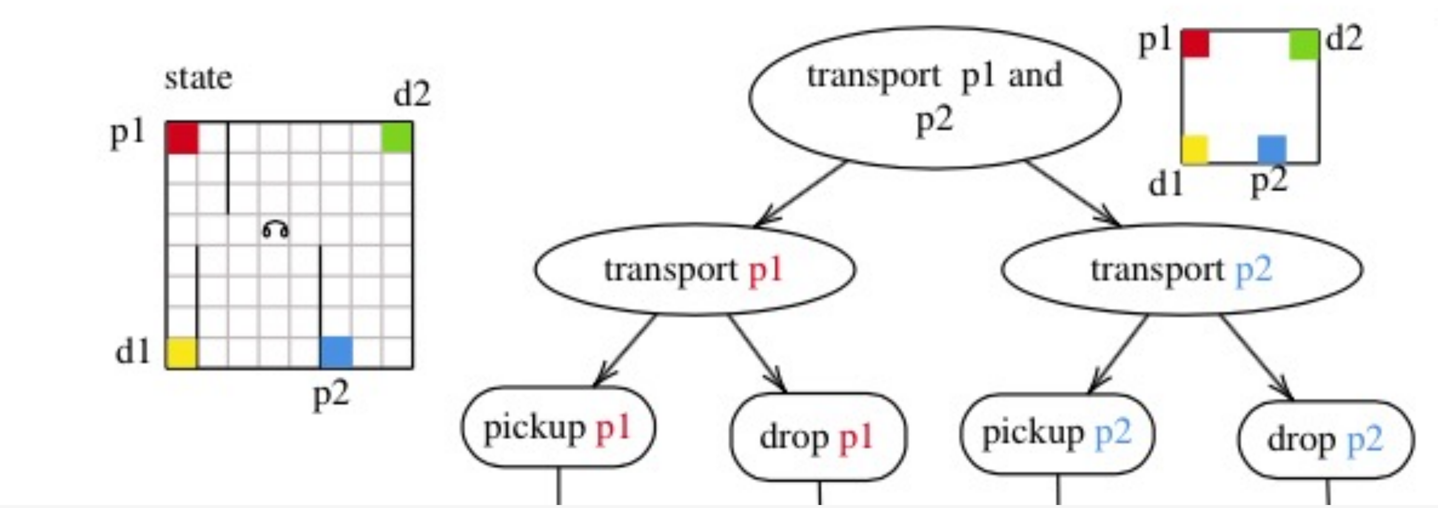
Goal:
Learning to act in relational domains with varying number of tasks and interacting objects

Proposed Solution:
Use a (relational) hierarchical planner to provide abstractions for the RL agents



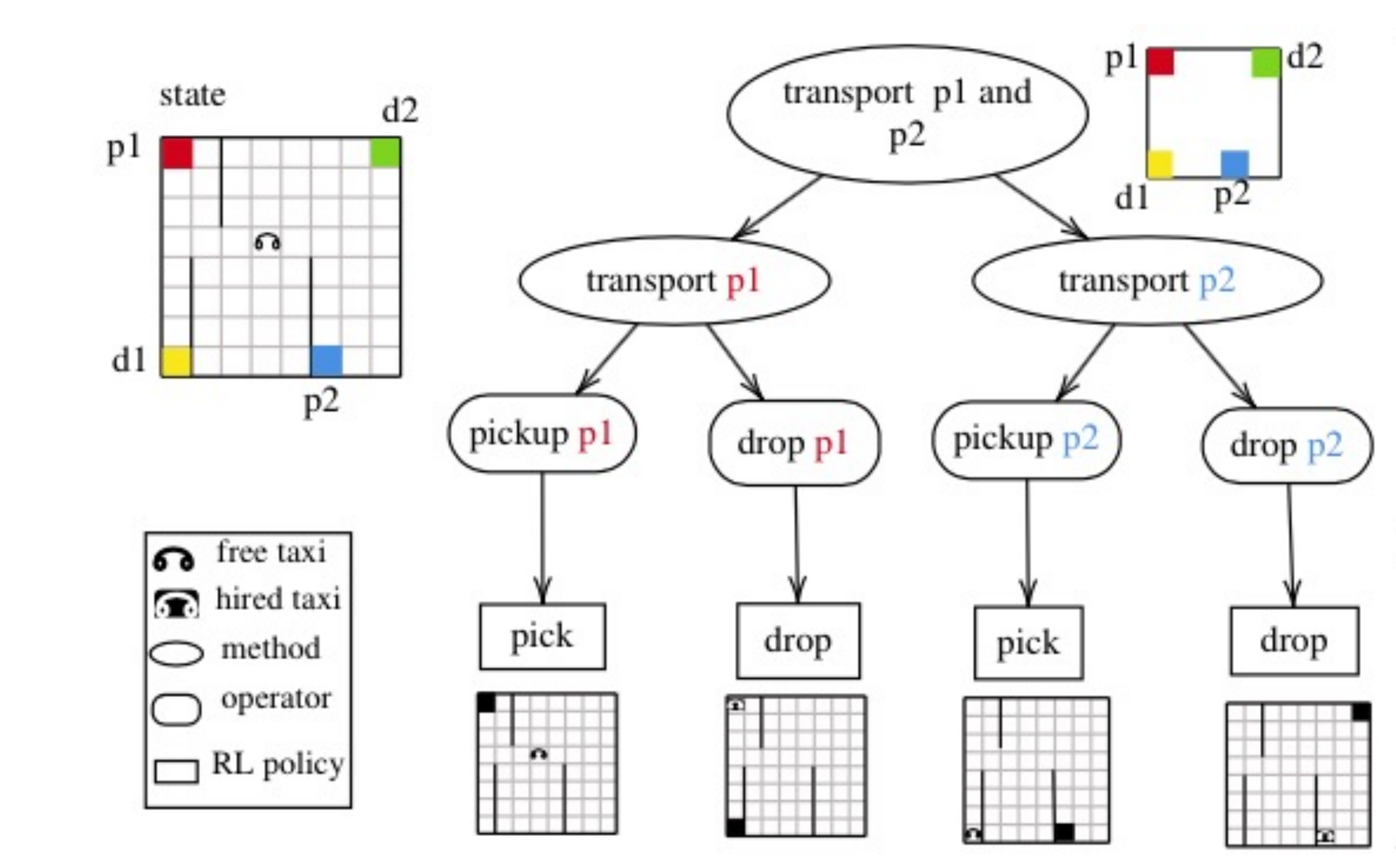
Toy Example

- Extended Taxi domain
- Planner provides sequence of passenger pickup and drop



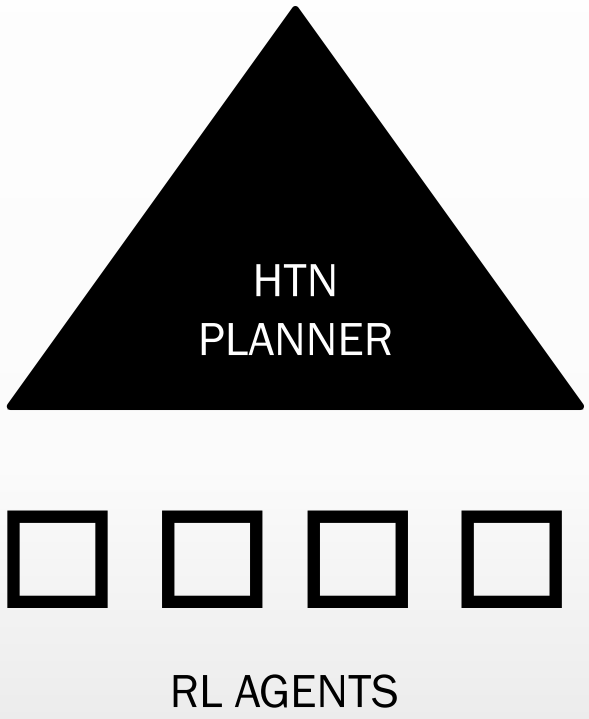
Toy Example

- Extended Taxi domain
- Planner provides sequence of passenger pickup and drop
- Learn driving route



RePReL

- Plan the sequence of operators at high level and learn to execute each operator at lower level
- Advantage:
  - *Compositionality*
  - *Task specific abstract representations*
- Relational MDP which is deterministic and fully observable
- Adapt First Order Conditional Influence statements to specify bisimulation conditions of MDPs for ‘safe’ abstractions.



Abstraction

First Order Conditional Influence (FOCI) statements

if $condition$ then X1 influence X2

Dynamic FOCI statements

$$\textbf{operator} \; : X1 \xrightarrow{+1} X2$$

Natarajan, Tadepalli, Dietterich, and Fern 2008

Abstraction

Given

State

$\{\text{at}(\text{p1}, \text{r}), \text{taxi-at}(13), \text{dest}(\text{p1}, \text{y}), \neg\,\text{at-dest}(\text{p1}), \neg\,\text{in-taxi}(\text{p1}), \text{at}(\text{p2}, \text{b}), \text{dest}(\text{p2}, \text{g}), \neg\,\text{at-dest}(\text{p2}), \neg\,\text{in-taxi}(\text{p1})\}$

subtask

$\langle\ \text{pickup}(P), \{P/p1, L/r\}\ \rangle$

D-FOCI

$\{\text{taxi-at(L1), move(Dir)}\} \xrightarrow{+1} \text{taxi-at(L2)}$

$\{\text{taxi-at(L1), move(Dir)}\} \longrightarrow R$

pickup(P):

$\{\text{taxi-at(L1), at(P, L), in-taxi(P)}\} \xrightarrow{+1} \text{in-taxi(P)}$

pickup(P): $\text{in-taxi(P)} \longrightarrow R_o$

Get

Abstract state

$\{\text{at}(\text{p1}, \text{r}), \text{taxi-at}(13), \neg\,\text{in-taxi}(\text{p1}), \text{move}(\text{Dir})\}$

Abstraction

Given

State: $\{\text{at}(\text{p1}, \text{r}), \text{taxi-at}(13), \text{dest}(\text{p1}, \text{y}), \neg\, \text{at-dest}(\text{p1}), \neg\, \text{in-taxi}(\text{p1}), \text{at}(\text{p2}, \text{b}), \text{dest}(\text{p2}, \text{g}), \neg\, \text{at-dest}(\text{p2}), \neg\, \text{in-taxi}(\text{p1})\}$

subtask: $\langle\ \text{pickup}(P), \{P/p1, L/r\}\ \rangle$

D-FOCI:

$$\{\text{taxi-at(L1), move(Dir)}\} \xrightarrow{+1} \text{taxi-at(L2)}$$
$$\{\text{taxi-at(L1), move(Dir)}\} \longrightarrow R$$
pickup(P):
$$\{\text{taxi-at(L1), at(P, L), in-taxi(P)}\} \xrightarrow{+1} \text{in-taxi(P)}$$
$$\text{pickup(P): in-taxi(P)} \longrightarrow R_o$$

Get

Abstract state: $\{\text{at}(\text{p1}, \text{r}), \text{taxi-at}(13), \neg\, \text{in-taxi}(\text{p1}), \text{move}(\text{Dir})\}$

safe model-agnostic abstraction

(Theorem 1)

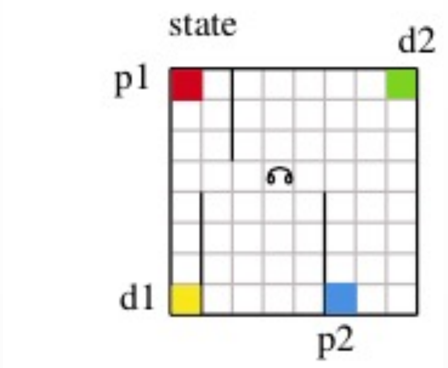
RePReL Learning Algorithm

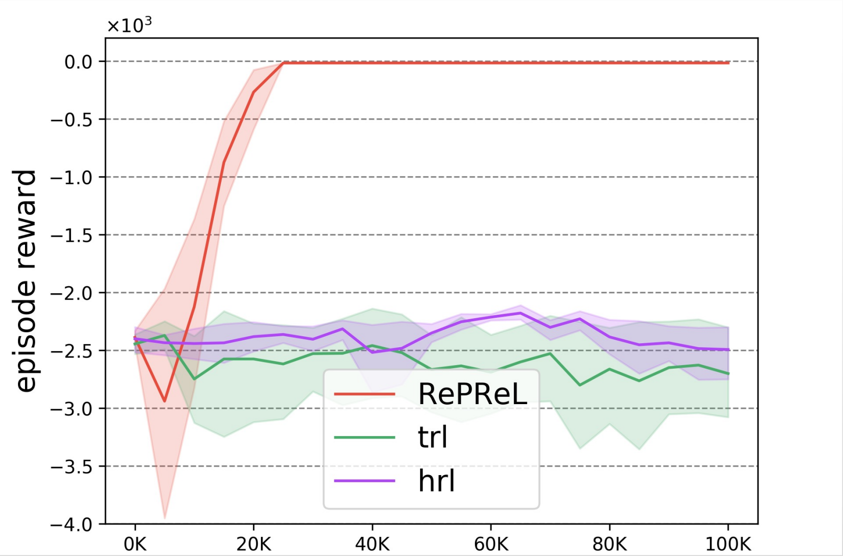
- Get high level plan
- For each sub-task
  - *Get resp. policy* π
  - *Loop till the sub-task is achieved*
    - Get the abstract state s
    - Get action a from the policy π
    - Step in env observe reward $\langle s, a, r, s' \rangle$
    - Update the policy π

*Q learning

Experiments

- Evaluate for
  - *Sample efficiency*
  - *Transfer across task*
  - *Generalization across objects*



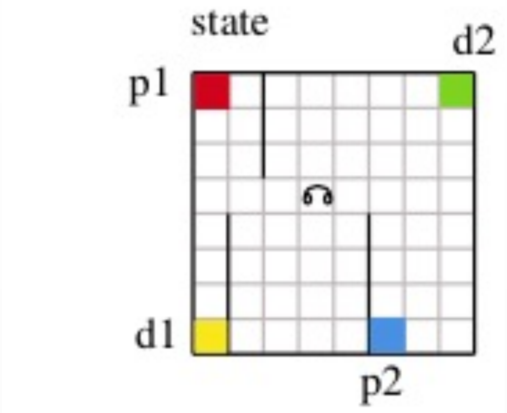


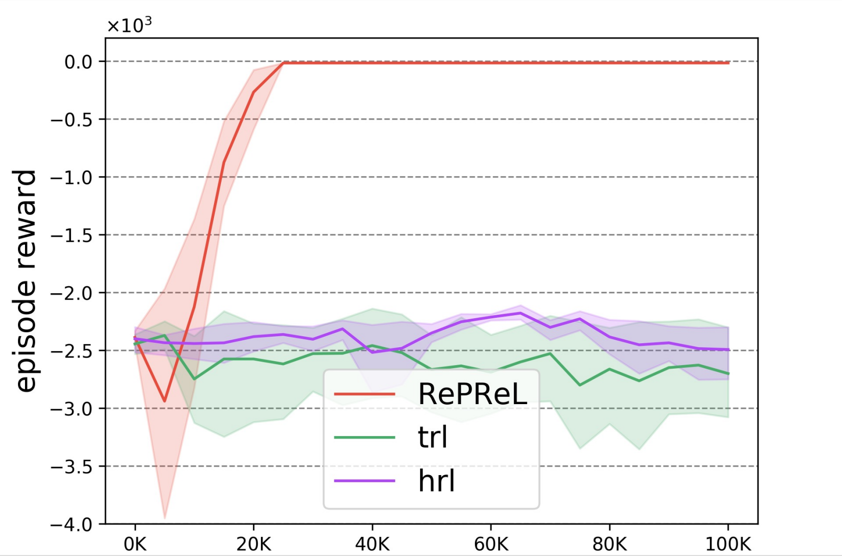
transport p1

trl: Taskable RL (Illanes et al. ICAPS 2020)

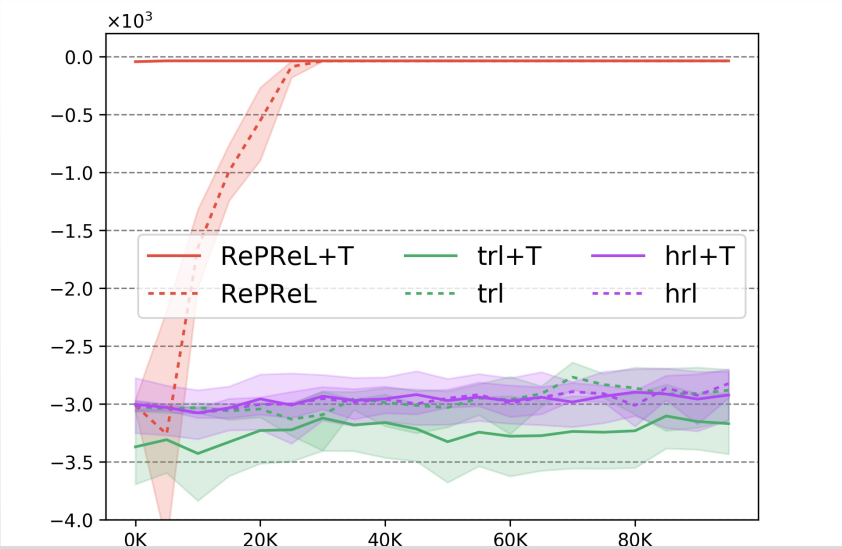
Experiments

- Sample efficiency
- Transfer across task
- Generalization across objects



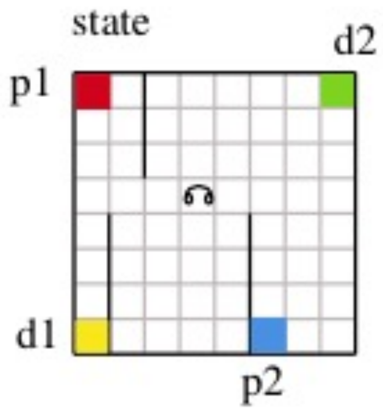


transport p1



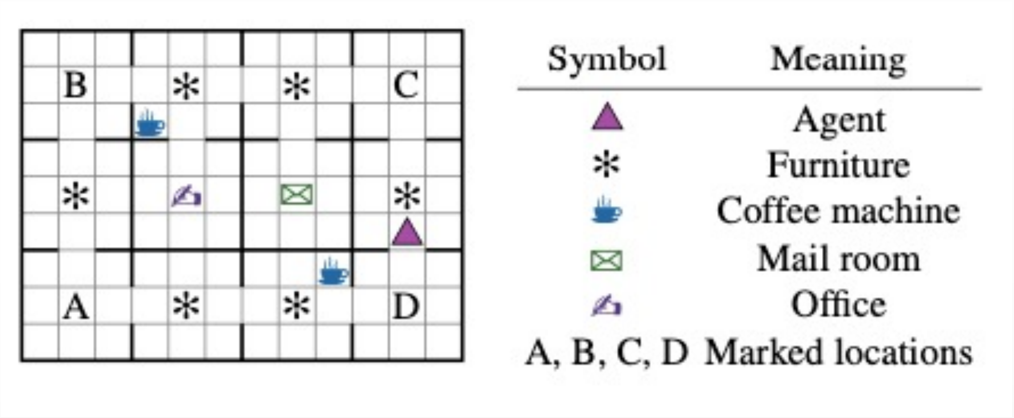
transport p1 and p2

Experiments

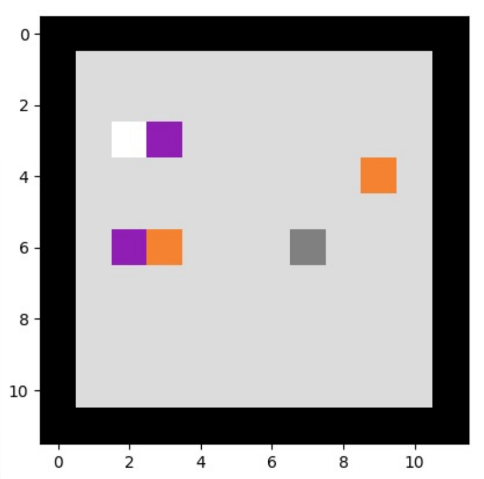


	state	abstract state (pick-up)
Relational {s}	$\mathrm{at}(\mathrm{p1},\mathrm{r}), \text{taxi-at}(13), \mathrm{dest}(\mathrm{p1},\mathrm{y}), \neg\,\text{at-dest}(\mathrm{p1}), \neg\,\text{in-taxi}(\mathrm{p1}), \mathrm{at}(\mathrm{p2},\mathrm{b}), \mathrm{dest}(\mathrm{p2},\mathrm{g}), \neg\,\text{at-dest}(\mathrm{p2}), \neg\,\text{in-taxi}(\mathrm{p1})\}$	$\{\mathrm{at}(\mathrm{p1},\mathrm{r}), \text{taxi-at}(13), \neg\,\text{in-taxi}(\mathrm{p1}), \mathrm{move}(\mathrm{Dir})\}$
Vector [s,a]	[at-p1, dest-p1, in-taxi-p1, at-dest-p2, at-p2, dest-p2, in-taxi-p2, at-dest-p2, taxi-at, move]	[at, taxi-at, in-taxi, move]

Experiments



Office world



Box world

Craft world

For human-level general intelligence, the ability to detect compositional structure in the domain and form task-specific abstractions are necessary.

THANKS