Endomorphisms of Lifted Planning Tasks

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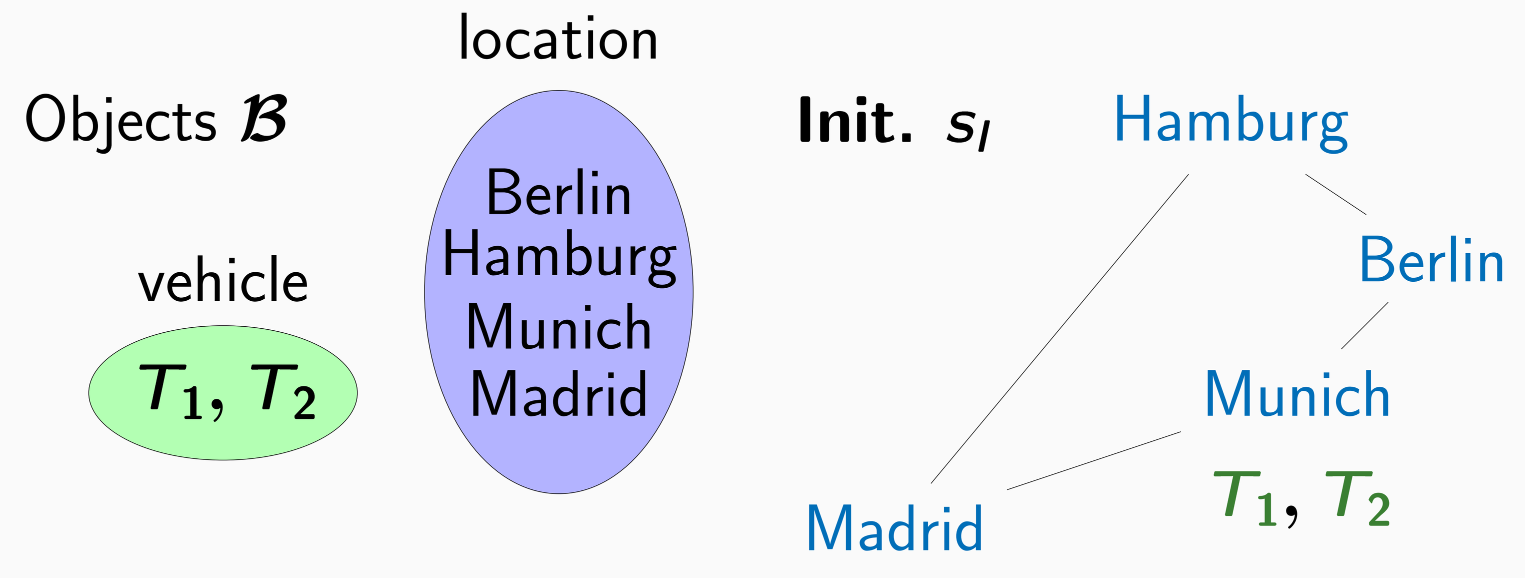
INTRODUCTION

We propose a method for automatic detection of redundant objects in PDDL tasks.

RUNNING EXAMPLE



Predicates:
at(v : vehicle, x : location), road(x : location, y : location)

Goal: at(T_1, Hamburg)

Action: drive(v, x, y) =
at(v, x) $\wedge$ road(x, y) $\Longrightarrow$ at(v, y) $\wedge \neg$at(v, x)

Redundant objects: Madrid, T_2

DESIGN CHOICES

$$\begin{tikzcd} s_I = s_0 \arrow[r, "\mathrm{drive}(T_1, \mathrm{Mun}, \mathrm{Mad})"] \arrow[d, "\sigma"'] & s_1 \arrow[r, "\mathrm{drive}(T_1, \mathrm{Mad}, \mathrm{Ham})"] \arrow[d, "\sigma"'] & s_2 \arrow[d, "\sigma"'] \\ s_I = t_0 \arrow[r, "\mathrm{drive}(\sigma T_1, \sigma \mathrm{Mun}, \sigma \mathrm{Mad})"] & t_1 \arrow[r, "\mathrm{drive}(\sigma T_1, \sigma \mathrm{Mad}, \sigma \mathrm{Ham})"] & t_2 \end{tikzcd}$$

- Keep the action schema, change only its instances.
- Represent mapping between tuples of objects by a map $\sigma : \mathcal{B} \to \mathcal{B}$, e.g., σMad = Ber and $\sigma x = x$ otherwise.
- σ has to be a homomorphism from s_i to t_i, e.g., if $s_i \models$ at(v, x) then $t_i \models$ at($\sigma v, \sigma$x).
- In particular, σ has to be an endomorphism on s_I.

PDDL ENDOMORPHISM

$\sigma : \mathcal{B} \to \mathcal{B}$ is a PDDL endomorphism if
(P1) σ preserves types, i.e., $\sigma(\tau) \subseteq \tau$ for all types τ,
(P2) σ is an endomorphism on s_I,
(P3) p($\vec{b}$) $\in$ Goal iff p($\sigma\vec{b}$) $\in$ Goal,
(P4) for all reachable states s, t and each ground action a($\vec{b}$)

$$\begin{tikzcd} s \arrow[r, "\mathrm{a}(\vec{b})"] \arrow[d, "\sigma"'] & s' \arrow[d, "\sigma"] \\ t \arrow[r, "\mathrm{a}(\sigma\vec{b})"] & t' \end{tikzcd}$$

(P5) for the optimal planning, we further assume that $\mathrm{cost}_{\mathrm{a}}(\sigma\vec{b}) \leq \mathrm{cost}_{\mathrm{a}}(\vec{b})$ for all ground actions a($\vec{b}$).

THEOREM

Let σ be a PDDL endomorphism. If
$\pi = \langle \mathrm{a}_1(\vec{b}_1), \ldots, \mathrm{a}_n(\vec{b}_n) \rangle$ is an (optimal) plan, then
$\pi' = \langle \mathrm{a}_1(\sigma\vec{b}_1), \ldots, \mathrm{a}_n(\sigma\vec{b}_n) \rangle$ is an (optimal) plan as well.

COROLLARY

If $b \notin \sigma(\mathcal{B})$ then b is redundant.

COMPUTATION

To find σ, we formulate the problem as an instance of CSP.
(P1-P3,P5) can be easily formulated as constraints in CSP.
(P4) is problematic due to delete effects. Suppose
$\sigma(T_2) = \sigma(T_1) = T_1$, σ(x) = x and σ(y) = y.

$$\begin{tikzcd} {\mathrm{at}(T_1, \mathrm{x}) \atop \mathrm{at}(T_2, \mathrm{x})} & & {\mathrm{at}(T_1, \mathrm{y}) \atop \mathrm{at}(T_2, \mathrm{x})} \\ s \arrow[rr, "\mathrm{drive}(T_1, \mathrm{x}, \mathrm{y})"] \arrow[d, "\sigma"'] & & s' \arrow[d, "\sigma"'] \arrow[d, phantom, shift left=4, "\times"] \\ t \arrow[rr, "\mathrm{drive}(T_1, \mathrm{x}, \mathrm{y})"] & & t' \\ \mathrm{at}(T_1, \mathrm{x}) & & \mathrm{at}(T_1, \mathrm{y}) \end{tikzcd}$$

WHAT CAN BE COLLAPSED?

{at(v, x)} is a lifted mutex group with v fixed and x counted. We cannot have at(T_1, x) $\wedge$ at(T_1, y) for x $\neq$ y in a reachable state s. Consequently, we cannot recreate the previous counter-example with two different locations.
The map σ defined by σMad = Ber and $\sigma x = x$ otherwise is an PDDL endomorphism so Madrid is a redundant object.

EXPERIMENTS

domain	#ps	%obj	%op	%fact
caldera18 (20)	20	15.15	0.00	0.00
citycar14 (20)	5	7.76	0.00	0.00
parcprinter11 (20)	6	7.28	0.00	0.00
...				
rovers06 (40)	33	3.84	11.32	6.43
satellite02 (20)	17	7.61	20.40	11.48
tpp06 (30)	1	2.22	13.44	0.42
transport11 (20)	11	4.65	9.28	7.63
visitall11 (20)	8	15.57	21.28	16.71
...				
overall from above (530)	244	5.83	5.33	3.61
overall from op-pruned (220)	106	5.99	12.26	8.31

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