Irrelevant Actions and Fluents in Plan Generation

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Example: Open the door

A door is initially locked, how to open it?

Available actions:

unlocking the door

opening it

posting a picture on it

- Solution 1: first unlock the door and post a picture on it simultaneously, and then open it.
- Solution 2: first unlock the door, and then open it.

The door domain in *C*+

Fluent constants: *locked, opened, posted*
Action constants: *unlock, open, post*

Causal laws:

constraint *locked* $\supset$ $\neg$*opened*

unlock **causes** $\neg$*locked*
nonexecutable *unlock* **if** $\neg$*locked*

open **causes** *opened*
nonexecutable *open* **if** *opened*

post **causes** *posted*
nonexecutable *post* **if** *posted*

exogenous *c* for every action constant *c*

inertial *c* for every fluent constant *c*

Two plans for solving the door problem

- Initial conditions: *locked*, $\neg$*posted*
- Goal: *opened*

Plan *A*

1. {*unlock*, *post*}
2. {*open*}

Plan *B*

1. {*unlock*}
2. {*open*}

Action *post* is irrelevant

If $e_1, e_2, \ldots, e_m$ is a solution to the door problem, then so is $e_1 \setminus \{post\}, e_2 \setminus \{post\}, \ldots, e_m \setminus \{post\}$.

Why? —— *post* is an irrelevant action to the goal *opened*.

Two "isolated" parts of the set of all constants:

$\{unlock, open, locked, opened\}$

$\{post, posted\}$

Plan *B* is a conformant solution to a modified problem

Incomplete initial conditions

Initial conditions: *locked*

Goal: *opened*

Is there a plan for all possible initial states?

s_{0a}: {*locked*, ¬*posted* }, s_{0b}: {*locked*, *posted* }

Plan *A* (×)

1. {*unlock*, *post*}
2. {*open*}

Plan *B* (√)

1. {*unlock*}
2. {*open*}

nonexecutable *post* **if** *posted*

Why?—— *posted* is an irrelevant fluent to the goal *opened*.

Other examples of irrelevant actions

- Exchanging hats by the missionaries and cannibals. (John McCarthy. Elaboration tolerance. 1999)

The action of exchanging hats is irrelevant to the goal of crossing the river.

- MS Word commands.

e.g. edit and paste are irrelevant to the goal of saving a file.

Isolated sets

- D: action description in C+
- σ^{all}: the set of all action and fluent constants in D

  A set $\sigma \subseteq \sigma^{all}$ is *isolated* if, for every causal law in D that contains a constant from σ, all the constants occurring in that law belong to σ also.

For instance:

constraint *locked* $\supset \neg$*opened*

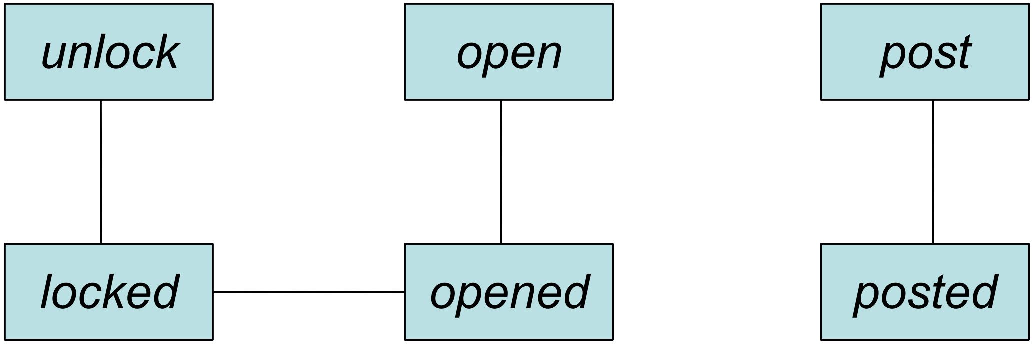
unlock **causes** $\neg$*locked*

open **causes** *opened*

-- If an isolated set contains at least one of the constants *unlock, open, locked, opened*, it must contain all four.

Isolated sets in the door domain

The graph shows that which constants occur in the same causal law.



Isolated sets: 1. $\emptyset$.

2. {*unlock, open, locked, opened*}.

3. {*post, posted*}.

4. {*unlock, open, locked, opened, post, posted*}.

Theorem

Assumption: For every state s, there exists a state s_1 such that $<s, \emptyset, s_1>$ is a transition.

Let D be an action description, and σ *a set of constants isolated with respect to D. For any history of D*

$$<s_0, e_0, s_1, \ldots, s_{m-1}, e_{m-1}, s_m>$$

there exist states $s'_1, \ldots, s'_m$ *such that*

$$<s_0, e_0 \cap \sigma, s'_1, \ldots, s'_{m-1}, e_{m-1} \cap \sigma, s'_m>$$

is a history also, and, for every $c \in \sigma^{fl} \cap \sigma$, $s'_i(c) = s_i(c)$ $(i=1,\ldots,m)$.

The theorem implies: If $e_1, e_2, \ldots, e_m$ is a solution to the door problem, then so is $e_1 \setminus \{post\}, e_2 \setminus \{post\}, \ldots, e_m \setminus \{post\}$.

Future work

- Extend the theorem to actions with attributes.
- Justify the use of isolated sets in conformant planning.
- Teach CCALC to identify isolated sets so that it can generate better plans, and probably more efficiently.