On semantics of STRIPS

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Outline

1. Introduction to STRIPS

2. Semantics of STRIPS

The STRIPS

- STRIPS: n. 1) An automated planner by Fikes and Nilsson in 1971 2) **The input language of the planner**.
- It operates on world models, represented by sets of formulas of first-order logic.
- World model are changed by *operators*.

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Building blocks of STRIPS

- Start with an arbitrary first-order language L.
- A *world model* is any set of sentences of L.
- An *operator description* is a triple of sentences of L, $\langle P, D, A \rangle$
  - P: precondition
  - D: delete list
  - A: add list

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An example

modified from original STRIPS paper

operator $pushto(X, Y)$: robot pushes object X next to Y

- Precondition: $pushable(X) \wedge nextto(robot, X)$
- Delete list: $atrobot(\$), nextto(robot, \$), nextto(\$, X), at(X, \$), nextto(X, \$)$
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Plans in STRIPS

- For a STRIPS system Σ, a *plan* is any finite sequence of its operators, denoted as $\bar{\alpha} = (\alpha_1, \ldots, \alpha_N)$ where $\alpha_i \in Op$, $\forall i \in 1..N$.

- A plan defines a sequence of world models $M_0, M_1, \ldots, M_N$, where M_0 is the initial world model and $M_i = (M_{i-1} \setminus D_{\alpha_i}) \cup A_{\alpha_i}$, $\forall i \in 1..N$.

- $\bar{\alpha}$ is accepted by the system if $M_{i-1} \vdash P_{\alpha_i}$, $\forall i \in 1..N$.

- We call M_N the result of executing $\bar{\alpha}$ and denote it as $R(\bar{\alpha})$.

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Interpreted STRIPS system

- The world described by language L at any instant is in a *state*.
- An action is a partial function from from states to states.
- If $f(s)$ is defined, we say that f is *applicable* in state s and $f(s)$ is the result of action f.
- We assume that each operator α in STRIPS is associated with an action f_α.
- A STRIPS system along with the information above is called an *interpreted* STRIPS system.
- For each plan $\bar{\alpha} = (\alpha_1, \ldots, \alpha_N)$ of an interpreted STRIPS system, we define $f_{\bar{\alpha}}$ to be the composite action $f_{\alpha_N} \ldots f_{\alpha_1}$.

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Soundness

How sound is STRIPS in describing a world?

Definition A

An operator description (P, D, A) is sound relative to an action f if, for every state s such that P is satisfied in s,

- f is applicable in state s,
- every sentence that is satisfied in s and does not belong to D is satisfied in $f(s)$,
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Soundness cond.

Is this semantics good?

Problems

- Atoms in the delete list of $pushto(X, Y)$ are obviously not the only sentences that may become false after action execution.
- Their conjunction or disjunction, e.g, $atrobot(\$) \wedge nextto(X, \$)$, or any sentence of the form $A \wedge F$ (A is an atom in delete list and F is any sentence in L) is also a such sentence. By definition A, the delete list will be infinite.
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- Thus, they have to be satisfied in all states.

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Second try on semantics

Definition B

An operator description (P, D, A) is sound relative to an action f if, for every state s such that P is satisfied in s,

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- every atomic sentence that is satisfied in s and does not belong to D is satisfied in $f(s)$,
- A is satisfied in $f(s)$ and every non-atomic sentence in A is satisfied in all states of the (future) world.

Σ is sound if M_0 is satisfied in the initial state s_0, each operator description $(P_\alpha, D_\alpha, A_\alpha)$ is sound relative to f_α, *and every non-atomic sentence in* M_0 *is satisfied in all states of the world.*

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"One more thing"

- The delete list of $push(X, Y)$ includes $nextto(robot, \$)$ but not $nextto(\$, robot)$.
- This is "a trick carefully planned by the authors."
- $nextto(\$, robot)$ never appears in initial model or add list of any operator.
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The general semantics of STRIPS

Suppose we have a special set E of ground atoms. Formulas from E is called *essential*.

Definition C

An operator description (P, D, A) is sound relative to an action f if, for every state s such that P is satisfied in s,

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Σ is sound if M_0 is satisfied in the initial state s_0, each operator description $(P_\alpha, D_\alpha, A_\alpha)$ is sound relative to f_α, *and every non-essential sentence in* M_0 *is satisfied in all states of the world.*

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