Structural Symmetries of the Lifted Representation of Classical Planning Tasks

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Motivation

- Recent interest in symmetries for planning:
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- In this work:
  - Reason about symmetries on lifted planning tasks
  - Provide the foundation for using structural symmetries for applications prior grounding

Outline

Abstract Structures

- S: set of symbols s with type $t(s)$
- Inductive definition of abstract structures:
  - $s \in S$ abstract structure
  - If $A_1, \ldots, A_n$ abstract structures, then also $\langle A_1, \ldots, A_n \rangle$ and $\{A_1, \ldots, A_n\}$ abstract structures

Structural Symmetries

- Symbol mapping σ: permutation of S with $t(\sigma(s)) = t(s)$
- Induced abstract structure mapping $\tilde{\sigma}$:

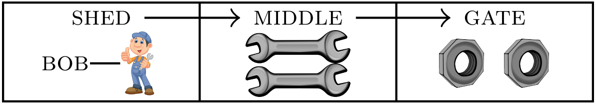
$$\tilde{\sigma}(A) := \begin{cases} \sigma(A) & \text{if } A \in S \\ \{\tilde{\sigma}(A_1), \ldots, \tilde{\sigma}(A_n)\} & \text{if } A = \{A_1, \ldots, A_n\} \\ \langle\tilde{\sigma}(A_1), \ldots, \tilde{\sigma}(A_n)\rangle & \text{if } A = \langle A_1, \ldots, A_n\rangle \end{cases}$$

- σ structural symmetry for abstract structure A if $\tilde{\sigma}(A) = A$

Lifted Planning Tasks as Abstract Structures

- Lifted representation: normalized PDDL with action costs
- Lifted planning task Π as abstract structure:
  - Components such as objects, variables, predicates etc: symbols
  - Atoms, literals, function terms, operators, axioms etc: composed abstract structures

Example Planning Task



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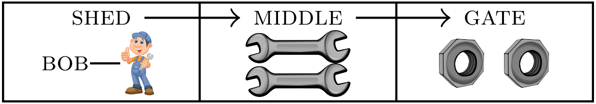

- Two symmetries on the lifted representation: nuts/spanners

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Theorem

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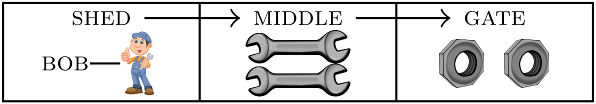

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- Other direction:
  - If σ symmetry of ground task Π (in our definition), then σ also symmetry of Π (in STRIPS)
  - If σ symmetry of lifted task Π, then σ also transition graph symmetry

Outline

Summarized Results

- Computation of symmetries as graph automorphisms
- 2518 in 77 domains (all sequential track IPC benchmarks)
- Only 9 domains without symmetries and 26 domains with majority of no symmetries
- 1430 of 2518 with symmetries
- Cheap to compute with one exception (ground task)

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- Future work:
  - Accelerated computation of invariants/grounding: consider only subset of (symmetric) objects
  - State space reformulations