Graphplan & SAT

PAH (Planning and Games)

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Graphplan

- Planning Graph
  - Efficient structure to explore the search-space
  - Fact layers, action layers, mutexes
- Graphplan
  - Construct PG until all goals reached
    - necessary but not sufficient
  - Try to extract plan
  - If no plan exists, expand PG (until fixed point)

Mutexes

- A mutex relation holds between **two actions when:**
  - *Inconsistent effects*
    - one action negates the effect of another.
  - *Interference*
    - one of the effects of one action is the negation of a precondition of the other.
  - *Competing needs*
    - one of the preconditions of one action is mutually exclusive with the precondition of the other.

- A mutex relation holds between **two literals when:**
  - One is the negation of the other OR
  - Each possible action pair that could achieve the literals is mutex (*inconsistent support*).

Example

- Dinner Date Problem
  - Propositions: garbage, cleanHands, dinner, quiet, present
  - Init: garbage, cleanHands, quiet
  - Goal: dinner, present, ¬garbage
  - Actions:
    - cook() {cleanHands} -> {dinner}
    - wrap() {quiet} -> {present}
    - carry() {} -> {¬garbage, ¬cleanHands}
    - vacuum() {} -> {¬garbage, ¬quiet}

Planning as SAT

- Init state formula (complete) – conj.
- Goal formula (incomplete) – conj.
- Each action in each step – impl.
  - Action in step i implies preconditions in i and effects in i+1
- Mutual exclusion formula – dis.
  - Only one action in each step
- Frame axiom formula – impl.
  - Change in prop. Value between states i and i+1 implies use of some action
- Action in every step formula – dis.

Example

- Robot moving between two lcations
- Propositions: at-A, at-B
- Init: at-A
- Goal: at-B
- Actions: move-A-B, move-B-A

Planning Graph as SAT

- Variables for fact and action nodes
- Precondition formula
  - $A_{i,m} \Rightarrow P_{j,m-1}$
- State progression formula
  - $P_{i,m} \Leftrightarrow (\bigvee_{p_i \in effects_{+(a_j)}} A_{j,m}) \vee (P_{i,m-1} \wedge (\bigwedge_{p_i \in effects_{-(a_j)}} \neg A_{j,m}))$
- Mutex relations, initial ang goal states