

Principles of AI Planning

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Exercise Sheet 2

Due: November 9th, 2012

Exercise 2.1 (Effect normal form, 2+2 points)

(a) Transform the operator

$$\langle \neg e \vee f, (a \triangleright (b \triangleright c)) \wedge (\neg d \triangleright c) \wedge (\neg(\neg c \wedge \neg a) \triangleright (d \wedge \neg e)) \wedge (d \triangleright \neg e) \rangle$$

into effect normal form and simplify it as much as possible. For each step, state which one of the equivalences (3) to (9) from the lecture you use. To save you some writing, you may apply the equivalences (1) (commutativity) and (2) (associativity) without explicitly mentioning it.

(b) Transform the ENF operator

$$\langle \neg e \vee f, (((a \wedge b) \vee \neg d) \triangleright c) \wedge ((c \vee a) \triangleright d) \wedge ((c \vee a \vee d) \triangleright \neg e) \rangle$$

into positive normal form. Again, in each step mark what you have done (e.g., “identify negative atom”). Remember that the transformation can destroy the ENF character!

Exercise 2.2 (Example for STRIPS regression, 2 points)

Consider the STRIPS planning task with atoms $A = \{a, b, c, d\}$, initial state $I = \{a \mapsto 1, b \mapsto 0, c \mapsto 0, d \mapsto 1\}$, goal $\gamma = a \wedge c$, and operators $O = \{o_1, o_2, o_3\}$, where

$$\begin{aligned} o_1 &= \langle b, c \rangle \\ o_2 &= \langle d, b \wedge \neg c \wedge \neg d \rangle \\ o_3 &= \langle d, a \wedge c \rangle. \end{aligned}$$

Solve this problem with a *breadth-first search* (BFS) using the STRIPS regression method. Submit the search tree that you obtain and record the solution plan. Do not expand a node further if the formula at that node is unsatisfiable or represents a set of states that is a (strict or nonstrict) subset of the set of states represented by the formula at a previously expanded node. Specify the result of regression for each node of the BFS tree.

Exercise 2.3 (Correctness of PNF transformation, 4 points)

Let $f(\Pi) = \langle f(A), f(I), f(O), f(\gamma) \rangle$ be the transformation of a planning task $\Pi = \langle A, I, O, \gamma \rangle$ into PNF. Prove the following statements.

- (a) For all formulas χ and states s , $s \models \chi$ iff $f(s) \models f(\chi)$.
- (b) Operator o is applicable in s iff $f(o)$ is applicable in $f(s)$.
- (c) If o is applicable in s , then $f(app_o(s)) = app_{f(o)}(f(s))$.

Note: The exercise sheets may and should be worked on in groups of two students. Please state both names on your solution (this also holds for submissions by e-mail).