Principles of AI Planning

R. Mattmüller, Prof. Dr. B. Nebel
T. Keller
Winter Term 2011/2012

University of Freiburg
Department of Computer Science

Exercise Sheet 2

Due: November 15th, 2011

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

(a) Transform the operator

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

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) Prove the following equivalences between effects:

$$\chi \rhd (e_1 \wedge e_2) \equiv (\chi \rhd e_1) \wedge (\chi \rhd e_2) \qquad (8')$$

$$(\chi_1 \rhd e) \wedge (\chi_2 \rhd e) \equiv (\chi_1 \vee \chi_2) \rhd e \qquad (9)$$

Exercise 2.2 (Example for STRIPS regression, 2 points)
Consider the STRIPS planning task with atoms $A = \{a, b, c, d, e\}$, initial state $I = \{a \mapsto 1, b \mapsto 1, c \mapsto 0, d \mapsto 0, e \mapsto 1\}$, goal $\gamma = b \wedge c$, and operators $O = \{o_1, o_2, o_3\}$, where

$$o_1 = \langle b \wedge d, c \wedge e \wedge \neg d \rangle$$
$$o_2 = \langle b, a \wedge \neg c \wedge \neg d \rangle$$
$$o_3 = \langle a, d \rangle.$$

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 STRIPS regression, 1+3 points)
Prove the correctness of STRIPS regression:
Let φ be a conjunction of atoms, $o = \langle \chi, e \rangle$ a STRIPS operator which makes the atoms $a_1, \dots, a_k$ true and the atoms $d_1, \dots, d_l$ false, and s an arbitrary state. Show:

(a) If o is *not* applicable in state s, then $s \not\models \mathit{sregr}_o(\varphi)$.

(b) If o is applicable in state s, then $s \models \mathit{sregr}_o(\varphi)$ iff $\mathit{app}_o(s) \models \varphi$.

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).