Planning and Optimization

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Exercise Sheet 2

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Note: As outlined in the lecture, we will denote conditional effects $(\top \rhd e)$ *by* e.

Exercise 2.1 (2 marks)

Consider the following operators and states:

(a) $o_1 = \langle c, (a \wedge \neg c \wedge d)\rangle$, $\quad s_1 = \{a \mapsto \mathbf{F}, b \mapsto \mathbf{T}, c \mapsto \mathbf{T}, d \mapsto \mathbf{T}\}$

(b) $o_2 = \langle c, ((a \wedge b) \rhd (c \rhd d)) \wedge \neg d\rangle$, $\quad s_2 = \{a \mapsto \mathbf{T}, b \mapsto \mathbf{T}, c \mapsto \mathbf{T}, d \mapsto \mathbf{F}\}$

(c) $o_3 = \langle c, ((a \wedge b) \rhd (c \rhd d)) \wedge \neg d\rangle$, $\quad s_3 = \{a \mapsto \mathbf{T}, b \mapsto \mathbf{T}, c \mapsto \mathbf{F}, d \mapsto \mathbf{F}\}$

(d) o_4 is the operator that increments a 4-bit counter as given in the lecture (chapter A4, slide 17 in the handout version):

$$\begin{aligned}
\mathrm{pre}(o_4) = & \neg b_0 \vee \neg b_1 \vee \neg b_2 \vee \neg b_3 \\
\mathrm{eff}(o_4) = & (\neg b_0 \rhd b_0) \wedge \\
& ((\neg b_1 \wedge b_0) \rhd (b_1 \wedge \neg b_0)) \wedge \\
& ((\neg b_2 \wedge b_1 \wedge b_0) \rhd (b_2 \wedge \neg b_1 \wedge \neg b_0)) \wedge \\
& ((\neg b_3 \wedge b_2 \wedge b_1 \wedge b_0) \rhd (b_3 \wedge \neg b_2 \wedge \neg b_1 \wedge \neg b_0)),
\end{aligned}$$

state $s_4 = \{b_0 \mapsto \mathbf{T}, b_1 \mapsto \mathbf{F}, b_2 \mapsto \mathbf{T}, b_3 \mapsto \mathbf{F}\}$.

Determine the update set of $\mathrm{eff}(o_i)$ in state s_i for $i = 1, \dots, 4$ by iteratively applying the rules from the lecture (chapter A4, slide 12 in the handout version).

Exercise 2.2 (2 marks)

Consider the operators and states from Exercise 2.1. Determine for $i = 1, \dots, 4$ whether o_i is applicable in s_i and, if yes, give the corresponding successor states.

Exercise 2.3 (2+2 marks)

Consider the following informal description of a planning task: there are two rooms A and B, a ball, and a robot with left and right hand. The ball can be located in room A or B, or in one of the robot's hands. If the robot and the ball are located in the same room, the robot can pickup the ball with its right or left hand such that it holds the ball in the corresponding hand. Conversely, if the robot holds the ball in any hand, it can drop the ball such that the hand is empty and the ball is located in the same room as the robot. Furthermore, the robot can drive between the rooms. Initially, both the ball and the robot are in room A, and the goal is to move the ball to room B.

(a) Provide a formal description Π of this planning task (chapter A4, slide 19 in the handout version). Use suitable sets of variables and operators.

(b) Provide the induced transition system of Π (chapter A4, slide 20 in the handout version) by depicting the part that is reachable from the initial state graphically. Indicate the initial state and the goal.

Exercise 2.4 (2 marks)
Transform the operator

$$\langle \neg e \lor \neg f, (b \rhd (c \rhd (\neg a \rhd (e \land \neg f)))) \land (e \rhd f) \land ((a \lor \neg b \lor \neg c) \rhd e)\rangle$$

to effect normal form (chapter A5, slide 11 in the handout version) by applying the algorithm from slides 15 and 16 (of the handout version of chapter A5). Provide the final operator in effect normal form and the intermediate operator effect resulting from each step of the algorithm.

Exercise 2.5 (2 marks)
Consider the planning task $\Pi = \langle V, I, O, \gamma \rangle$ with

$$\begin{aligned}
V =& \{\mathit{haveCake}, \mathit{haveQuiche}, \mathit{haveSugar}, \mathit{hungry}\} \\
I =& \{\mathit{haveCake} \mapsto \mathbf{F}, \mathit{haveQuiche} \mapsto \mathbf{F}, \mathit{haveSugar} \mapsto \mathbf{T}, \mathit{hungry} \mapsto \mathbf{T}\} \\
O =& \{\langle \neg \mathit{haveCake} \lor \neg \mathit{haveQuiche}, (\mathit{haveSugar} \rhd (\mathit{haveCake} \land \neg \mathit{haveSugar})) \land (\neg \mathit{haveSugar} \rhd \mathit{haveQuiche}), \\
& \langle \mathit{haveCake}, \neg \mathit{haveCake} \land \neg \mathit{hungry} \rangle, \\
& \langle \mathit{haveQuiche}, \neg \mathit{haveQuiche} \land \neg \mathit{hungry} \rangle \\
\gamma =& \mathit{haveCake} \land \neg \mathit{hungry}
\end{aligned}$$

Transform Π to positive normal form (Chapter A6, slide 7 in the handout version).

The exercise sheets can be submitted in groups of two students. Please provide both student names on the submission.