Principles of AI Planning

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Exercise Sheet 3

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Exercise 3.1 (Regression, 4 points)
Consider the following situation: Romeo and Juliet are at home.

$$I(p) = 1 \text{ iff } p \in \{\textit{romeo-at-home}, \textit{juliet-at-home}\}$$

Juliet wants to go dancing, but Romeo wants to stay at home.

$$\gamma = \textit{juliet-dancing} \land \textit{romeo-at-home}$$

Since this is a real couple, Romeo can't just say that he doesn't want to go dancing – if Juliet goes dancing and he is at home, he has to join her. This is modelled by the following operator:

$$\begin{aligned} \textit{go-dancing} = \langle & \textit{juliet-at-home}, \\ & \textit{juliet-dancing} \land \neg\textit{juliet-at-home} \land \\ & (\textit{romeo-at-home} \rhd (\textit{romeo-dancing} \land \neg\textit{romeo-at-home}))\rangle \end{aligned}$$

Of course, Romeo can always pretend he has work to do:

$$\textit{go-work} = \langle \textit{romeo-at-home}, \textit{romeo-at-work} \land \neg\textit{romeo-at-home}\rangle$$

Since he would not want to stay at work forever, we must also model the inverse operator:

$$\textit{go-home} = \langle \textit{romeo-at-work}, \textit{romeo-at-home} \land \neg\textit{romeo-at-work}\rangle$$

We thus obtain the planning problem

$$\begin{aligned} \langle & \{\textit{romeo-at-home}, \textit{romeo-dancing}, \textit{romeo-at-work}, \\ & \textit{juliet-at-home}, \textit{juliet-dancing}\}, \\ & I, \{\textit{go-dancing}, \textit{go-work}, \textit{go-home}\}, \gamma\rangle \end{aligned}$$

Solve this problem with regression *breadth-first search* (BFS) without splitting. Submit the search tree that you obtain and record the solution plan. At every node of the search tree, simplify the state formula as much as possible (with the rules given in Chapter 5, slide 57/63) and do not expand the node further if the formula at that node is unsatisfiable or identical to the formula at a previously expanded node. During expansion, use the operator ordering *go-work*, *go-home*, *go-dancing*. Specify the result of regression for each node of the BFS tree.

Exercise 3.2 (Full splitting and unrestricted regression, 3+3 points)

(a) Consider the planning task with atoms $A = \{a_1, a_1', a_2, a_2', a_3, a_3', a_4\}$, the initial state I where exactly the atoms a_2 and a_3 are true, goal formula $\gamma = a_4$, and operators $O = \{o_1, o_2, o_3\}$, where

- $o_1 = \langle \top, \big((a_1 \land a_1') \lor (\neg a_1 \land \neg a_1')\big) \rhd (a_2 \land a_2')\rangle$,
- $o_2 = \langle \top, \big((a_2 \land a_2') \lor (\neg a_2 \land \neg a_2')\big) \rhd (a_3 \land a_3')\rangle$, and
- $o_3 = \langle \top, \big((a_3 \land a_3') \lor (\neg a_3 \land \neg a_3')\big) \rhd a_4\rangle$.

Solve this task with regression BFS and *full splitting* and specify the search tree that you obtain. At every node of the search tree, simplify the state formula as much as possible (using the rules given in Chapter 5, slide 57/63) and do not expand a node further if the formula at that node is unsatisfiable or represents a set of states that is a subset of a set of states already represented by a formula at a previously expanded node or at an unpruned sibling node.

Hint: To keep the figure clear, you may omit nodes that are not expanded.

(b) The given task is a member of a familiy of planning tasks where full splitting is both an efficient method regarding the size of the state formula *and* the number of created nodes. Generalize the example to a family of planning tasks of size $O(n)$ for $n \in \mathbb{N}$, with n operators (instead of 3) and $2n + 1$ state variables (instead of 7) such that the task given above is the one for $n = 3$. Compare the asymptotic number of expanded nodes and the size of the largest state formula occuring in the search tree under regression BFS if full splitting is used to the case where it is not used.

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).