Principles of AI Planning

Prof. Dr. B. Nebel, Dr. R. Mattmüller
D. Speck, T. Schulte, M. Kantz
Winter Semester 2019/2020

University of Freiburg
Department of Computer Science

Exercise Sheet 4

Due: Friday, November 22th, 2019

Send your solution to `mario.kantz@gmail.com` (PDF only) or submit a hardcopy before the lecture. The exercise sheets may and should be worked on and handed in in groups of two or three students. Please indicate all names on your solution.

Exercise 4.1 (Example for general regression, 6 points)

Consider the following situation: Romeo and Juliet are at home.

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

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

$$\gamma = \mathit{juliet\text{-}dancing} \wedge \mathit{romeo\text{-}at\text{-}home}$$

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:

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

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

$$\mathit{go\text{-}work} = \langle \mathit{romeo\text{-}at\text{-}home}, \mathit{romeo\text{-}at\text{-}work} \wedge \neg \mathit{romeo\text{-}at\text{-}home}\rangle$$

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

$$\mathit{go\text{-}home} = \langle \mathit{romeo\text{-}at\text{-}work}, \mathit{romeo\text{-}at\text{-}home} \wedge \neg \mathit{romeo\text{-}at\text{-}work}\rangle$$

We thus obtain the planning problem

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

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 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 4.2 (Exponential plan length, 4 points)

Show that for all $n \in \mathbb{N}$ there is a conditional effect free planning task $\Pi = \langle A, I, O, \gamma\rangle$ with $|A| = |O| = \mathcal{O}(n)$ such that $|\pi| = \mathcal{O}(2^{|n|})$ where $|\pi|$ is the length of a plan. Informally, this proves that the shortest plan of a planning task Π can be exponential in the size of Π, where the size of a planning task is the number of variables and operators. *Hint:* Try to construct a family of planning tasks where the execution of the shortest plan visits each state once.