Planning and Optimization

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Exercise Sheet 4

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Exercise 4.1 (5 marks)

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

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

Juliet likes to go dancing, but Romeo prefers to stay at home.

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

Since this is a real couple, Romeo cannot just say that he does not want to go dancing—if Juliet goes dancing and he is at home, he has to join her. This is modeled by the following operator:

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

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

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

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

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

Based on I and γ defined as above, we thus obtain the planning task $\langle V, I, O, \gamma\rangle$ with

- $V = \{\text{romeo-at-home}, \text{romeo-dancing}, \text{romeo-at-work}, \text{juliet-at-home}, \text{juliet-dancing}\}$, and
- $O = \{\text{go-dance}, \text{go-work}, \text{go-home}\}$.

Solve this problem with a breadth-first search using the regression method (full regression, no splitting). Provide 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 that formula is unsatifiable or identical to a previously encountered node. When expanding nodes, use the operator order go-work, go-home, go-dancing (i.e., go-work is applied first, go-dancing is applied last). Provide the result of the regression in each node of the search tree. You can stop the search as soon as a formula is generated that is satisfied by I.

Exercise 4.2 (2+2 marks)

Provide a family of planning tasks Π_n such that the size of Π_n is polynomial in n, and such that

(a) a breadth-first search with regression expands only a polynomial number of search nodes in n, whereas a breadth-first search with progression needs to expand an exponential number of search nodes in n.

(b) a breadth-first search with progression expands only a polynomial number of search nodes in n, whereas a breadth-first search with regression needs to expand an exponential number of search nodes in n.

Please turn around

Exercise 4.3 (1.5+1.5 marks)

In this exercise, we consider regression for SAS^+ planning tasks.

(a) Define regression $sas\_regr_o(\varphi)$ for SAS^+ planning tasks. Analogously to the regression for general planning tasks, for a finite-domain operator o and a formula φ, the regressed formula $sas\_regr_o(\varphi)$ needs to characterize exactly those states from which after the application of o, the formula φ is satisfied.

Hint: The definition of $sas\_regr_o(\varphi)$ only needs to consider conjunctions φ of atomic formulas, as in SAS^+ planning tasks, the goal is a conjunction of atomic formulas, and regressing a conjunction with a finite-domain operator yields a conjunction of atomic formulas again.

(b) For SAS^+ planning tasks in transition normal form, it is even possible to perform regression search by performing progression search on a transformed version of the planning task. Provide the transformation and explain why it is correct.

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