Principles of AI Planning

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Exercise Sheet 2

Due: Friday, November 4th, 2016

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

(a) Transform the operator

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

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) Transform the ENF operator

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

into positive normal form. Again, in each step mark what you have done (e.g., "identify negative atom"). Remember that the transformation can destroy the ENF character!

Exercise 2.2 (PDDL, 2+1+2+1 points)

The *set cover* problem can be formalized as follows: Given a finite set $\mathcal{U}$ and a collection of subsets $\mathcal{S} = \{S_1, \dots, S_n\}$ with $S_i \subseteq \mathcal{U}$ for all $S_i \in \mathcal{S}$, find a subcollection $\mathcal{C} = \{C_1, \dots, C_m\} \subseteq \mathcal{S}$ with $C_1 \cup \dots \cup C_m = \mathcal{U}$. The *minimum set cover* problem is about finding a *cardinality minimal* such subcollection $\mathcal{C}$. See `http://en.wikipedia.org/wiki/Set_cover_problem` for more details.

The following exercise can and should be solved with the fully featured PDDL online editor (`http://editor.planning.domains/`). Send your solution files (with all names mentioned) via email to `david.speck@pluto.uni-freiburg.de`.

(a) Create a file called *domain.pddl* and model the set cover problem as a PDDL domain using types `set` and `elem`, predicates `(contains ?s ?e)` for sets `?s` and elements `?e`, `(selected ?s)` for sets `?s`, and `(covered ?e)` for elements `?e`. Moreover, use a schematic operator `(select-set ?s)` for putting sets `?s` into subcollection $\mathcal{C}$, thus covering their elements. You will need universal and conditional effects for that. In order to be allowed to use them, specify the PDDL requirement `:adl`.

(b) Create a file called *problem.pddl* and model the following set cover instance as a PDDL problem file: $\mathcal{U} = \{e_1, e_2, e_3, e_4\}$, and $\mathcal{S} = \{S_1, S_2, S_3, S_4, S_5\}$ with $S_1 = \{e_1\}$, $S_2 = \{e_2, e_3\}$, $S_3 = \{e_4\}$, $S_4 = \{e_1, e_2\}$, and $S_5 = \{e_3, e_4\}$.

(c) Solve the set cover instance from above. More specifically, press `Solve` and select "Domain: *domain.pddl*", "Problem: *problem.pddl*" and "Custom Planner URL: `http://fd-solver.herokuapp.com`". Report the plan found by the integrated planner and state to which set cover $\mathcal{C}$ this plan corresponds. Is the plan optimal?

(d) Explain how the distinction between optimal and satisficing planning on the one hand and the distinction between arbitrary and cardinality minimal set covers are related. You may refer to the formalization of the set cover problem as planning that you used above. Similarly, how are plan existence and existence of a set cover related in our setting?

You may and should solve the exercise sheets in groups of two. Please state both names on your solution.