Principles of AI Planning

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Exercise Sheet 2

Due: Friday, November 8th, 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 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 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 them.

(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, state what you have done (e.g., “identify negative atom”). Remember that the transformation can destroy the ENF character!

Exercise 2.2 (PDDL set cover, 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 $\mathcal{S} = \{S_1, \ldots, S_n\}$ with $S_i \subseteq \mathcal{U}$ for all $S_i \in \mathcal{S}$, find a subcollection $\mathcal{C} = \{C_1, \ldots, C_m\} \subseteq \mathcal{S}$ with $C_1 \cup \cdots \cup C_m = \mathcal{U}$. 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.

This exercise may 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 Mario Kantz (`mario.kantz@gmail.com`).

(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 using `http://editor.planning.domains/`. 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?