Principles of AI Planning

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Exercise Sheet 11

Due: Friday, January 18th, 2019

Send your solution to `drexlerd@tf.uni-freiburg.de` or submit a hardcopy before the lecture.

Exercise 11.1 (Weak plan existence problem, 2+3 points)

Show that the decision problem whether a plan exists for a given (fully observable) nondeterministic planning task is PSPACE-complete by proving its PSPACE hardness and PSPACE-membership.

(a) Show that the weak plan existence problem is PSPACE-hard.

(b) Show that the weak plan existence problem is in PSPACE.

Hint: The all-outcome determinization of a planning task is definied as follows.

Definition 1 (all-outcomes determinization)**.** *Let* $\Pi = \langle V, I, O, \gamma \rangle$ *be a nondeterministic planning task. The* all-outcomes determinization *of* Π *is the deterministic planning task* $\Pi_{\text{det}} = \langle V, I, O_{\text{det}}, \gamma \rangle$*, where* $O_{\text{det}} = \bigcup_{o \in O} o_{\text{det}}$*, and* $\langle \chi, E \rangle_{\text{det}} = \{\langle \chi, e \rangle \mid e \in E\}$*.*

For example, assume a non-deterministic operator *flip-coin* with two different results: head and tail. The all-outcome determinization of *flip-coin* generates two operators *flip-coin-head* and *flip-coin-tail* with the effect of head and tail. In other words, you can think of Π_{det} as a deterministic version of Π where the planner can decide the result of each operator. In order to prove the PSPACE-membership of the weak plan existence problem you can make use of the fact that the all-outcome determinization of a planning task is computable in polynomial time.

Exercise 11.2 (Problem modeling, 2+2+1 points)

Note: 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 Dominik Drexler (`drexlerd@tf.uni-freiburg.de`).
Rovers operating on other planets must be autonomous, because signals from Earth to planets deep in our solar system take too long.

(a) Model a rover domain with the following specification. There are several waypoints on the planet, some of which are connected. The rover can navigate between two waypoints A and B when A and B are connected. Interesting rocks can be found at any waypoint. The rover can only analyze the rocks of a waypoint when it is at the waypoint. After the rover has analyzed a rock sample, it can transmit the results of this particular analysis to Earth. The transmission of the results of analysed rock samples can only be carried out at certain waypoints where the connection to Earth is good enough. Note that each result is to be transferred via an individual action. All actions have unit costs.

(b) Model the problem of the rover domain shown in Figure 1. The goal is to analyze all rock samples and transfer the results to Earth.

(c) Solve the rover problem 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.

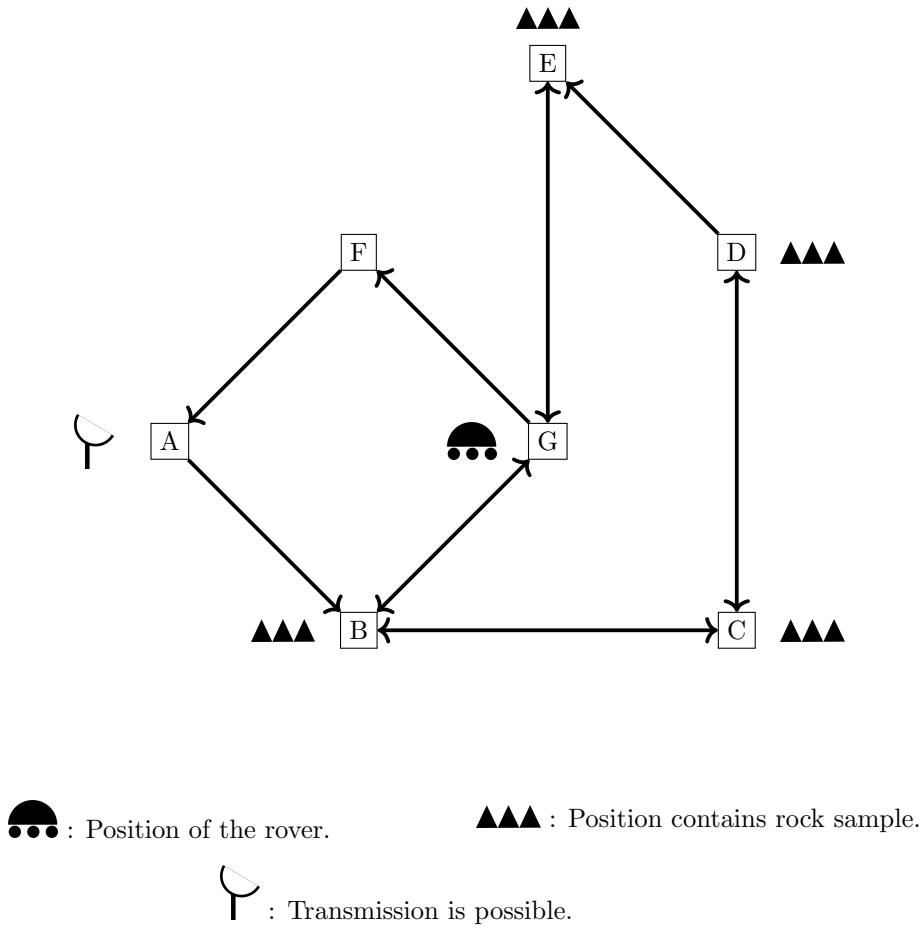

Figure 1: A problem of the rover domain.

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