

Einführung in Künstliche Intelligenz SS 2017, 2.0 VU, 184.735

Exercise Sheet 3 – CSPs, Planning, and Making Simple Decisions

For the discussion part of this exercise, mark your solved exercises in **TUWEL** until Monday, June 05, 23:55 CET. Be sure that you tick only those exercises that you can solve and explain!

In the discussion, students will be asked questions about their solutions of examples they checked. The discussion will be evaluated with 0-15 points, which are weighted with the fraction of checked examples and rounded to the next integer. There is *no minimum number of points* needed for a positive grade (i.e., you do not need to participate for a positive grade, but you can get at most 85% without doing exercises).

Please ask questions in the **TISS** Forum or visit our tutors during the tutor hours (see **TUWEL**).

Exercise 3.1: Consider the following cryptarithmic puzzle. Every letter corresponds to exactly one digit. In particular, the digits corresponding to different letters are different and *M* should not be 0 or 9.

$$\begin{array}{r} \text{H U M A N} \\ + \text{S N A K E} \\ \hline \text{M E D U S A} \end{array}$$

- Describe the corresponding CSP with its variables and constraints and specify the initial domain of each variable.
- Find a solution of the puzzle.

Exercise 3.2:

- Given a single ternary constraint $A + B = C$. Transform this constraint into 3 binary constraints achieving the same functionality using auxiliary variables.
- Show how unary constraints can be eliminated by altering the domains of variables.

Exercise 3.3: Consider the following planning problem: You are given three containers C_1 , C_2 , and C_3 . Thereby, C_1 contains a red package, C_2 a green package, and C_3 is initially empty. Using a roboter arm, you can access the contents of the containers. You can use the following actions:

Action(*Grasp*(x, y, z),
Precond: $empty \wedge full(y, x) \wedge pos(y)$
Effect: $hold(x) \wedge free(y) \wedge pos(z) \wedge \neg empty \wedge \neg full(y, x) \wedge \neg pos(y)$)

Action(*Ungrasp*(x, y, z),
Precond: $pos(x) \wedge free(x) \wedge hold(y)$
Effect: $empty \wedge full(x, y) \wedge pos(z) \wedge \neg pos(x) \wedge \neg free(x) \wedge \neg hold(y)$)

The meaning of the predicates is as follows:

- $empty$: roboter arm is empty;
- $hold(x)$: roboter arm holds x ;

- $pos(y)$: roboter arm is over container y ;
- $full(x, y)$: container x contains package y ;
- $free(x)$: container x is empty.

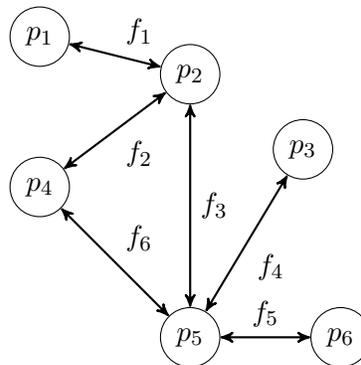
The initial state S is $\{empty, pos(C_1), full(C_1, r), full(C_2, g), free(C_3)\}$.

The goal state is $\{full(C_1, g), full(C_2, r), pos(C_3)\}$.

Find the shortest possible plan for getting from the initial state to the goal state. Use the STRIPS state-space search algorithm starting in S , i.e., use *progression planning*.

Exercise 3.4: Consider a situation where a space traveler is in a galaxy far away that is in a state of war between different planets. The goal for our adventurer is to find a safe and peaceful planet. Therefore, he explores the different planets of the galaxy by traveling between them. For getting from one planet to another, the two planets must be connected by an intergalactic space ferry which is still operating. Unfortunately, not all space ferries are operating—some might be shut down temporarily. The traveler is able to reinstall space ferries that have been shut down if he is on one of the planets that it connects.

- Design two STRIPS actions, one for reinstalling space ferries and one for traveling from one planet to a connected one. Introduce variables for modeling the different aspects of this exercise and describe them in detail.
- Assume the galaxy in which the space traveler resides contains the planets p_1, \dots, p_6 . The planets are connected by different ferries as indicated by the arrows between them. Suppose our traveler is at planet p_1 and wants to travel to planet p_6 . Furthermore, suppose that the ferries f_2, f_3 , and f_6 are shut down. Formulate the initial state of this concrete planning setting. Furthermore, find a plan to get the traveler from planet p_1 to planet p_6 using progression planning.



Exercise 3.5: Assume there is a lottery with tickets for 50 Dollar and there are three possible prizes: 120\$ with a probability of $\frac{1}{8}$, 100\$ with probability $\frac{1}{4}$, and 5\$ else.

- What is the expected monetary value of a lottery ticket?
- When is it rational to buy a ticket? Give an equation involving utilities with the following utilities: $U(S_k) = 0$, $U(S_{k+50}) = 6 \cdot U(S_{k+5})$, $U(S_{k+100}) = 1.5 \cdot U(S_{k+50})$, but there is no information about $U(S_{k+120})$.

Exercise 3.6: In 1713, Nicolas Bernoulli investigated a problem, nowadays referred to as the *St. Petersburg paradox*, which works as follows. You have the opportunity to play a game in which a fair coin is tossed repeatedly until it comes up heads. If the first head appears on the n -th toss, you win 2^n dollars.

- (a) Show that the expected monetary value of this game is not finite.
- (b) Daniel Bernoulli, the cousin of Nicolas, resolved the apparent paradox in 1738 by suggesting that the utility of money is measured on a logarithmic scale, i.e., $U(S_n) = a \log_2 n + b$, where S_n ($n > 0$) is the state of having n dollars and a, b are constants. What is the expected utility of the game under this assumption? Assume, for simplicity, an initial wealth of 0 dollars and that no stake has to be paid in order to play the game.