SAPIENZA
UNIVERSITÀ DI ROMA

Artificial Intelligence

2024/2025 Prof: Sara Bernardini

Lab 12:
Exam simulation n.3

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*The slides have been prepared using the textbook material available on the web, and the slides of the previous editions of the course by Prof. Luigia Carlucci Aiello, Prof. Daniele Nardi and Dott. Fabio Previtali.

Exercise 1

1. Model the following domain in PDDL:

   A robotic agent needs to take care of a very big house. The house has 3 floors, and it is arranged as follows:

   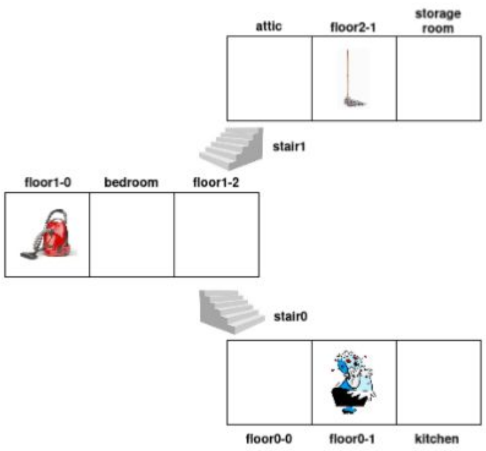

   Figure 1: House domain

   The robot needs to do the following tasks:

   - clean the kitchen (floor 0);
   - clean the bedroom (floor 1);
   - clean the attic (floor 2).

   In addition to that, he has to wash the 2 stairs. To clean the rooms, he uses a vacuum cleaner (located in the room **floor1-0**). To wash the stairs, he uses a mop (located in the room **floor2-1**). The robot starts with no item and can carry only one item at the time. Once a stair is washed, the robot cannot use it anymore (otherwise it gets dirty again!). To clean the stairs, the robot must be in the room above them). Eventually, the two items must be deposited in the storage room to consider the task completed.

2. Write the PDDL problem file for the problem.

3. Give an example of a plan that solves the problem that you just modeled.

Consider the game tree within the two players Max and Min depicted in Figure 2. Max is the next to move.

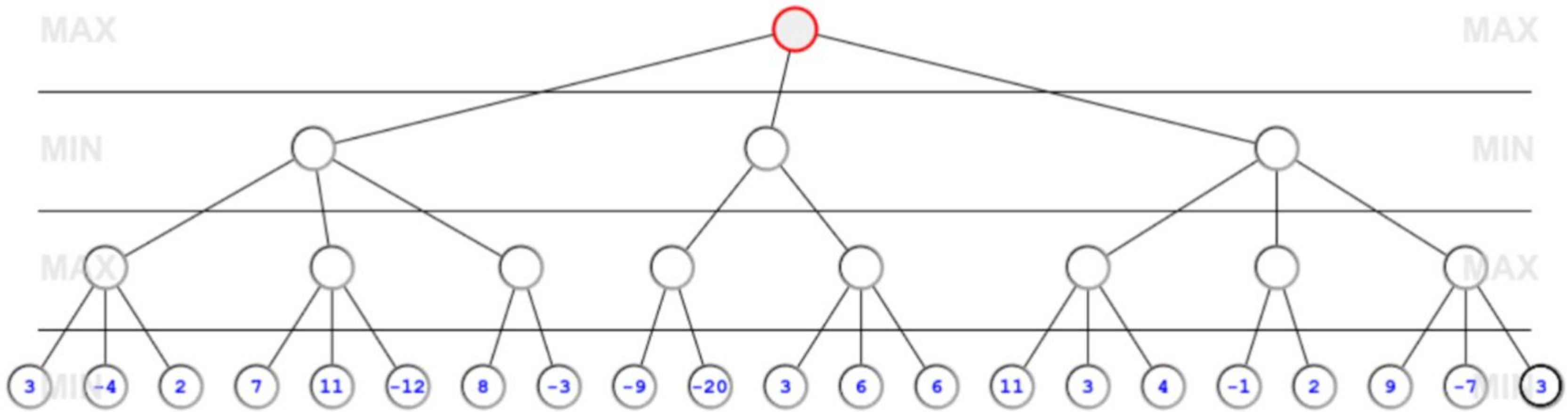

Figure 2: Game tree

a) Run the Minimax algorithm. What is Max's next move?

b) Run the Alpha-beta pruning algorithm. Show at every internal node the alpha and beta values and how they change throughout the algorithm.

c) What are the properties of Minimax in terms of complexity, completeness, and optimality? How much do we improve the search when using the Alpha-beta pruning technique (in the best case)?

Exercise 3

1. All printers make noise during use. Anyone who has any staplers will not have any tape dispensers. Managers do not have anything which makes noise during use. Alex has either a stapler or a printer.

   a) Translate the sentences above in **FOL (First Order Logic)**. Define a vocabulary for the constants, predicates, and functions you need.

   b) Translate the sentences in CNF (Conjunctive Normal Form).

   c) Prove that: If Alex is a manager, then Alex does not have any tape dispensers.

2. Given the following FOL formulas:

   - $\forall x \exists y \forall z (P(x.y) \rightarrow Q(z, x))$
   - $\exists x \forall y \exists z (R(y, z) \wedge \neg S(x, y))$
   - $\forall x \forall y \exists z \exists w (P(x, y, z) \vee Q(w, y))$
   - $\exists x \exists y \forall z (P(z) \rightarrow \exists w Q(x, y, w))$

   a) Write their Skolemized forms.

   b) Why is the Skolem normal form useful?

Exercise 4

Consider the following constraint network: $\gamma = (V, D, C)$:

- Variables: $V = \{a, b, c, d, e, f\}$
- Domains: for all $v \in V, D_v = \{1, 2, 3, 4, 5\}$
- Constraints: $a = b - 2,\ c = a + 3,\ e = c + 1,\ b = 2f + 1,\ d = b - 1,\ c = b + 1$

a) Draw the constraint graph γ.

b) Run the **AC-3** algorithm on the given constraint network. For each iteration, give the content of the data structure M at the start of the iteration, the pair (u, v) removed from M, the domain D_u of u after the call to Revise (γ, u, v), and the pairs (w, u) added into M. Note: Initialize M as a lexicographically ordered list (i.e., (a, b) would be before (a, c), both before (b, a) etc., if any of those exist). After initialization, use M as a FIFO queue, i.e., always remove the first (oldest) element from the queue and add new elements to the end of the queue.

c) Give the complete assignment of the variables.

d) Is it possible to apply the AyclicCG algorithm on γ to find a solution? If yes, please explain why. If not, please explain why.