SAPIENZA
UNIVERSITÀ DI ROMA

Artificial Intelligence

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Lab 10:
Exam simulation n.1

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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

The robotic arm in Figure 1 needs to pile some cylinders up in the location P10. More specifically, it must pile them up in the following order: C2 on top of C0, C0 on top of C1, and C1 on the location P10. However, P10 is dirty and must be first cleaned by using the tissue that is located in location P11. After cleaning P10, the tissue must return to its place. Constraints: the robot can only hold one item at a time (either a cylinder or the tissue) and can only pick a cylinder if no other cylinder is on top of it.

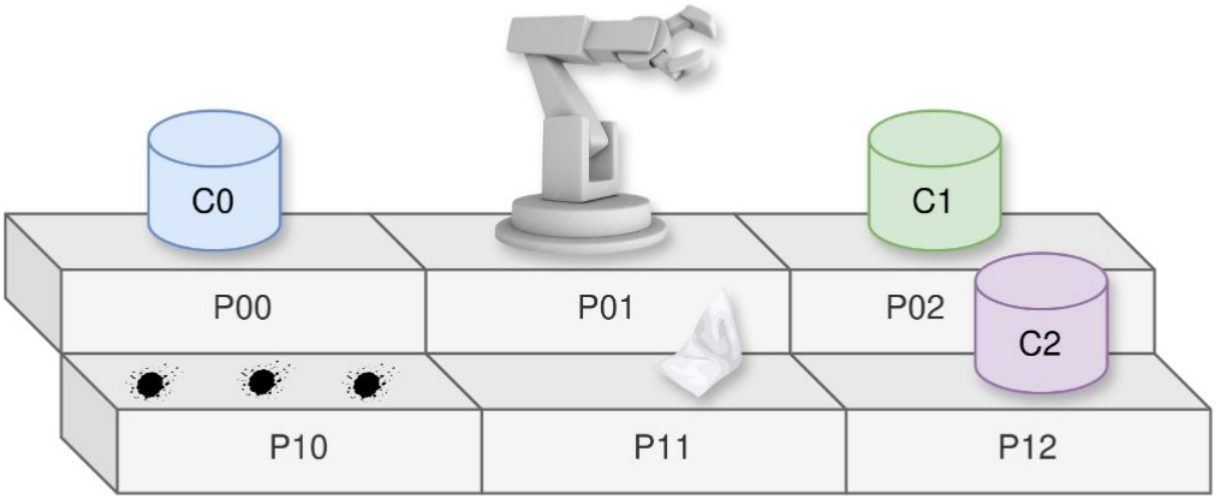


Figure 1: Initial state of the domain.

a) Model the problem in PDDL (Problem Domain Definition Language) and define the domain.

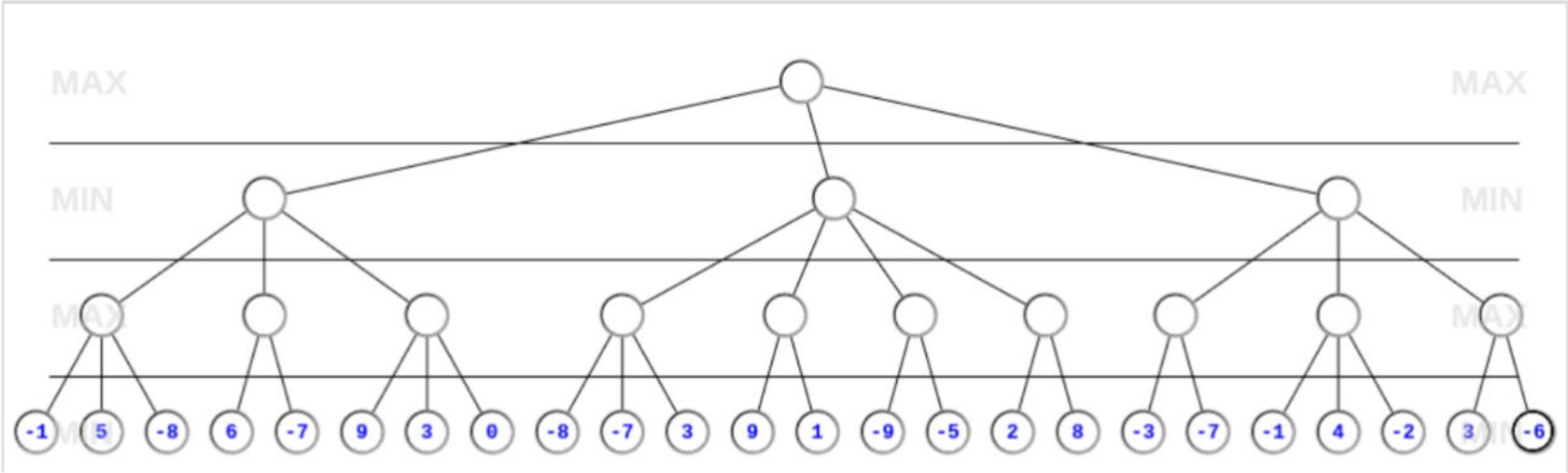
b) Based on the domain file in point a), define the problem.

c) Show one possible sequence of actions (plan) leading the robot from the initial state to the goal state.

d) How would you model this problem to apply local search? Which local search algorithms would you apply and which not? Do you think local search would be particularly suitable for this problem? Motivate each of your answers.

Exercise 2

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



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

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

Exercise 3

1. Erika is the owner of two dogs: Fido and Pluto. Dogs that have owners are happy if their owner feeds them. Erika loves her dogs. Everybody feeds those they love if food is available.

   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) showing the transformations of the formulas.

   c) Tell whether it is possible to prove that "Fido and Pluto are happy" **via resolution**. If it is not possible, which knowledge is needed to make such an inference?

2. Given the following two formulas:

$$R(h(X), f(h(b), Y)) \quad \textit{and} \quad R(Y, f(Y, h(g(a))))$$

   (a) Can they be unified? If so, show the unification process.

   (b) If they can be unified, write the Most General Unifier.

   Note: capital letters are variables, and lowercase letters are constants.

3. Given the following KB: $\Delta = \{\{A, \neg C\}, \{B, C, E\}, \{B, \neg E\}, \{\neg A, C\}, \{D, E\}, \{B, \neg D\}, \{\neg D, \neg E\}, \{A, C\}\}$, apply the DPPL algorithm with clause learning and show the various iterations of the algorithm. Assume that the variables are selected in alphabetical order and that the splitting rule attempts the value "False" first.

Exercise 4

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

- Variables: $V = \{a, b, c, d, e, f, g\}$
- Domains: for all $v \in V, D_v = \{1, 2, 3, 4, 5, 6\}$
- Constraints: $e = 2a,\ b = e,\ c = e + 1,\ d = 2c - 2,\ f = 2e + 1,\ g = f - 2$

a) Draw the constraint graph γ.

b) Draw the constraint graph of γ and consider running the AcyclicCG algorithm on it. In particular, pick **e** as the root, draw the directed tree obtained, and give the resulting variable ordering. If the ordering of the variables is not unique, break ties using alphabetical order.

c) Complete the execution of the AcyclicCG algorithm by listing the calls to $Revise(\gamma, v_{parent(i)}, v_i)$ and, for each of them, give the resulting domain of $v_{parent(i)}$.

d) Give the complete assignment of the variables.

e) Is it possible to apply the AC-3 algorithm on γ to find a solution? Give the answer and motivate it.