Artificial Intelligence

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First Name and Last name

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The results of the exams of all the students will be posted in a single file in the Moodle web page. Each student will be identified only by his/her 'Matricola' code (Sapienza registration number). If you do not agree on having your grade listed in this file, please check this box:

NO-WEB [ ]

Maximum time is 75 minutes. You can use neither the text books nor your notes.

Students enrolled in the academic year 2019/20 in the Master Degree in Artificial Intelligence and Robotics, please check this box: [ ].

Students enrolled in the academic year 2018/19, 2017/18, 2016/17 in the Master Degree in Artificial Intelligence and Robotics, please specify year of enrolment:

Students enrolled in academic year 2019/20 in the Master Degree Engineering in Computer Science and any other curricula that include a 6 ECTS course in Artificial Intelligence, please check this box: [ ]

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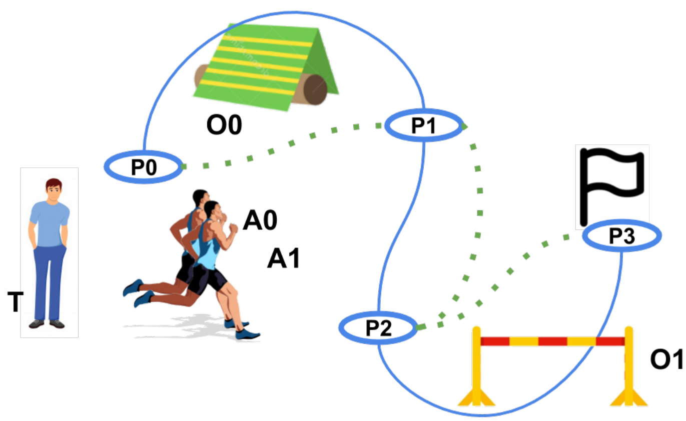
Search and Planning

Exercise 1 (8 points)

Two athletes $A0, A1$ and trainer T are preparing for a competition in the training setting shown in the figure. They start in $P0$ and they have to be all in $P3$ in order to finish a trial. Connections among places are highlighted by two paths: the athlete path (solid) and the trainer path (dotted). $A0, A1$ can only use the athlete path and they must jump over the first obstacle $O0$, and then crouch and pass underneath the second $O1$. T instead, can only walk the trainer path. Agents cannot move simultaneously, only one agent can move at each step from one place Pi to the next place in the path. Moreover, the trainer has to stay one or more steps ahead, to check the performance of the athletes, thus $A0$ and $A1$ must never anticipate T (i.e. they are allowed to be only in places already visited by T). Athletes and trainer can be all together in the same location of the training path. For example, if T is in $P2$ then $A0, A1$ can be in $P0, P1$ or $P2$. The athletes can take steps in arbitrary order (i.e. they can always agree on who makes the next step).



(a) Model the problem in PDDL by defining the problem and domain file.

(b) Define a plan that achieves the goal of having the athletes and the trainer in $P3$, given the initial configuration in the figure with all the agents in $P0$; show each state in the plan, by specifying the initial state and the changes caused by each action.

(c) Draw the first 5 levels of the tree generated by forward search, showing all the actions applicable at each of the states that are traversed in the plan found in (b), without further expanding the states that do not belong to the plan.

Exercise 2 (4 points)

Discuss the notion of local search, in particular describe genetic algorithms and provide an example.

Exercise 3 (4 points)

Define the notion of *belief state* and make an example. Discuss how the uncertainty on the state affects the representation of plans and the planning process.

Knowledge Representation

Exercise KR1 (8 points)

Given the following sentences:
1. students that like meat, eat at lunch bread and salami
2. students that like vegetables, eat at lunch bread and salad
3. students that do not like meat, like vegetables
4. Francesco is a student

and the following vocabulary:

Constants: $bread, salami, salad, francesco.$
Predicates: $student(x), likeMeat(x), likeVeg(x), eatAtLunch(x, y)$ (where x is the eater and y the eaten food).

(a) Write the KB that models the above sentences.

(b) Transform it in CNF and tell whether there are any non-Horn clauses.

(c) Derive using resolution that *Francesco eats at lunch.*

(d) Write two models for the above KB.

Exercise KR2 (4 points)

Define the notion of *non monotonic reasoning*, and make examples to illustrate it. In particular, discuss the *closed world assumption* in propositional logic, highlighting its limitations.

Exercise KR3 (4 points)

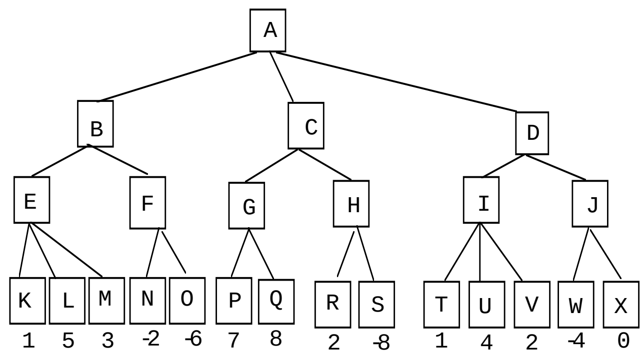
Consider a data structure list, whose elements are lists of two atoms, such that the two atoms in each list are not equal (e.g. `[[a,b],[c,d],[e,f]]`), and call it **LA**.

- (a) Write a Prolog program `isLA(X)`, that checks whether its argument is an **LA**.
- (b) Write a Prolog program `makeLA(X,Y)`, that, given an input list `X`, returns an **LA** `Y`, obtained by removing all elements of `X`, that do not match the structure of the **LA** (i.e. lists of two equal atoms, lists where one element is a list instead of an atom, lists that are longer or shorter than 2). The predicate `atom(X)` checks whether its argument is an atom.
- (c) [**EXTRA QUESTION tbd only after having answered everything else**] An **LA** represents a function of finite domain, if the first elements of each list are are all different atoms. The function is invertible if all the second atoms of each list are different. Write a Prolog program `one2one(X)`, which checks whether `X` is the representation of an invertible function.

Section 2A: MAS and SHRI

Exercise 1 (11 points)

Consider a game with two players *min* and *max*. *min* moves first; *max* replies and the game includes another play by *min*. The terminal nodes show the utility values for *min*. The game tree is given in the figure.



1. Using the minmax algorithm, compute the minmax value of the root node and identify the minmax decision at the root.

2. Determine which parts of the game tree can be pruned using the alpha-beta pruning technique

Exercise 2 (11 points)

Describe the main approaches to task assignment in a multi agent systems. How can cooperation in Robot soccer be casted as a task assignment problem?

Exercise 3 (11 points)

Discuss the main approaches to syntactic analysis. Choose an example of sentence in English and give the result of the syntactic analysis for each of the parsing methods described earlier.