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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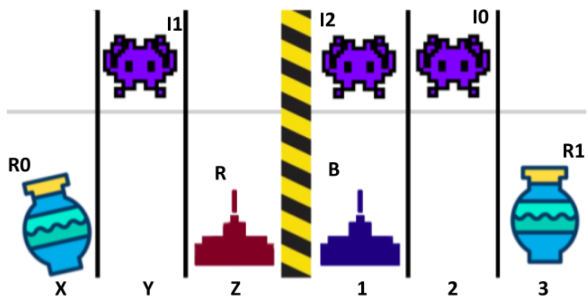
Search and Planning

Exercise 1 (8 points)

Two spaceships R and B are searching for two relics ($R0, R1$). In order to complete their mission, they must defeat their enemies ($I0, I1, I2$) and collect the relics. The world of R and B is represented as a simple gridworld with one row and 6 columns; B can only navigate cells labelled with numbers (1, 2, 3), while R can only navigate cells labelled with letters (X, Y, Z). R and B can shoot to destroy other ships, but they must do it immediately after entering the location where the enemy is, otherwise they will be destroyed. Importantly, R and B must coordinate, and the relics can be taken only after all the enemies have been destroyed.



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

(b) Starting from the initial state shown in the figure, define a plan that achieves the goal of having R and B holding the relics ($R0, R1$) at X and 3, respectively; 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)

Define the notion of heuristics for heuristic search, providing examples. Sketch the main techniques to obtain heuristics for a given search problem.

Exercise 3 (4 points)

Discuss the difference between state-space and plan-space planning. Describe the basic approach to plan space planning (POP). Discuss the application of POP planning to the problem presented in the previous exercise.

Knowledge Representation

Exercise KR1 (8 points)

Given the following sentences:
1. Every program, except those written by experts, has a bug.
2. All the programs in my PC are Prolog programs.
3. My prolog programs are bug-free.
and the following vocabulary:

Predicates: $bugFree(x), inMyPC(x), program(x), prologProgram(x), writtenByExpert(x)$
(if needed, use shortcuts $bF(x), inMyPC(x), pr(x), prP(x), wBE(x)$.

A) Express the sentences in FOL and translate them in CNF. Tell whether the resulting KB is Horn.

B) Can one infer (using resolution) that: *All programs in my PC are written by an expert*?

C) Write the following sentences in first-order logic, using $S(x)$ for slow, $St(x, y)$ to mean that x is slower than $y, C(x)$ for car, $B(x)$ for blue, and $W(x, r)$ for car x winning race r.

1. All blue cars are slow.
2. All slow cars are blue.
3. Some slow cars are blue.
4. There is a car winner in every race.

Exercise KR2 (4 points)

Describe the language of *description logics*, and make examples to illustrate it. In particular, write the concept of *doctors, all of whose patients are cured* and show an interpretation that satisfies the concept.

Exercise KR3 (4 points)

Consider a data **ALBMAX**, which is a binary tree storing natural numbers on its nodes, such that the number stored in a node is the max of the numbers of the nodes in its children.

- (a) Write a Prolog program `isALBMAX(X)`, that checks whether its argument is an **ALBMAX**.
- (b) Write a Prolog program `filterALBMAX(X,Y)`, that, given an input list `X` of binary trees, returns a list of all the binary trees contained in `X` that are **ALBMAX**.
- (c) [**EXTRA QUESTION tbd only after having answered everything else**] Write a Prolog program `singleALBMAX(X,Y)` that takes in input `X`, which is an **ALBMAX** and returns `Y`, which is a list of the leaves, whose values are not stored in their father. No specific ordering is required for the elements in the list `Y`.

Section 2A: MAS and SHRI

Exercise 1 (11 points)

Discuss the notion of alpha-beta pruning in searching game trees for two player games. What are the properties of alpha-beta pruning? Provide an example of game tree, where alpha-beta pruning can be successfully applied.

Exercise 2 (11 points)

Provide the formal definition of Distributed Constraint Optimization Problem. Sketch the DPOP algorithm for Distributed Constraint Optimization.

Exercise 3 (11 points)

Describe the notion of Part-Of-Speech (POS): basic approaches, tools and state of the art performances.