Artificial Intelligence — Final Test

July 11, 2022

Hand-in instructions

The test must be submitted through the link available on the Aulaweb page for the course “Artificial Intelligence for Robotics 1”. The answers for sections 1 and 2 should be submitted in handwritten form in .pdf format (you can use pen-enabled devices or scan handwritten answers on paper). Please try to be as clear as possible. You must supply text files for the answer to section 3. Overall, your hand-in should be a single zipped file < *student_id* >_<*surname*>, and if you have more than one surname, please use camel case (not spaces) to separate words.

During the test you do not have to keep your webcam switched on and you can consult your notes and other references on your PC or the internet (the exam is open-book). You must not ask help to your fellow colleagues or others. By submitting the exam, you implicitly state that you are adhering to this policy.

1 Propositional Logic

Given the following formulas in propositional logic

- φ_1: $(p \rightarrow q)$
- φ_2: $(q \rightarrow (s \wedge t))$
- φ_3: $(r \rightarrow (s \wedge t))$
- φ_4: $(p \vee r)$

show whether the formula $s \wedge t$ is a logical consequence of the theory $\Phi = \{\varphi_1, \varphi_2, \varphi_3, \varphi_4\}$. State your answer as a proof using either a deduction mechanism of your choice. Truth-tables are not accepted as an answer.

2 First Order Logic

Consider the following model for the “sorority world” where an “$\times$” in the cell x, y denotes that x “likes” y

	Abby	Bess	Cody	Dana
Abby	$\times$	-	$\times$	$\times$
Bess	-	$\times$	-	$\times$
Cody	-	-	$\times$	-
Dana	-	$\times$	$\times$	-

and tell which of the following sentences is true in the model:

1. $\forall x.likes(x, x)$
2. $\forall x.\exists y.likes(x, y)$
3. $\exists y.\forall x.likes(x, y)$
4. $\forall x.\forall y.likes(x, y) \rightarrow likes(y, x)$
5. $\forall x.\forall y.(\exists z.likes(x, z) \wedge likes(z, y)) \rightarrow likes(x, y)$.

3 Planning

Use PDDL-STRIPS to formalize a domain where a robot with two grippers can move around a set of rooms and collect objects, considering the following constraints:

- Some objects are heavy and some are light; heavy objects require the robot to use both grippers to carry them, whereas light objects can be carried using only one grippper; therefore the robot can carry only one heavy object or two ligth ones.
- The rooms are numbered from 1 to n and they are connected with a corridor, so the robot can move back and forth to any room.
- A room may contain objects or be empty.
- The robot must be in the room to collect an object in it.
- The object must be dropped in a room to be considered there.

In particular, formalize actions to move from one room to another and collect/drop objects, as well as the predicates to characterize the state. Formalize a problem instance where there are four rooms, the agent is initially in room 1, there are two objects (one light and one heavy) located in room 2 and two objects (one light and one heavy) located in room 3 and the goal is to carry all of them in room 4. Write in the problem file as a comment what would you expect to be the optimal plan (the one featuring the least number of steps).