Artificial Intelligence for Robotics I

Final Test

February 2nd, 2024

Hand-in instructions

The answers for Propositional and First Order Logic questions can be submitted in handwritten form to the teacher, or in .pdf format (you can use pen-enabled devices or scan handwritten answers on paper) through the link made available on the Aulaweb page for the course "Artificial Intelligence for Robotics 1". Please try to be as clear as possible in your handwriting. The answer to the Planning question is to be submitted through Aulaweb, and you must supply two text files in PDDL language for your answer, one named `domain.pddl` for the domain and one named `problem.pddl` containing the definition of the problem instance. 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 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: $(p \to q)$
- φ_2: $(r \to (s \wedge t))$
- φ_3: $(p \vee r)$
- φ_4: $(\neg p \vee q) \wedge (p \vee r)$
- φ_5: $(q \to (s \wedge t))$

show whether the formula $s \wedge t$ is a logical consequence of the theory $\Phi = \{\varphi_1, \varphi_2, \varphi_3, \varphi_4, \varphi_5\}$. 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 first order theory about dressing tastes:

1. $\forall x.(Likes(x, sneakers) \vee Likes(x, boots))$.
2. $\forall x.(Likes(x, slipon) \rightarrow Likes(x, boots))$.
3. $\exists x.\neg Likes(x, slipon)$.
4. $\exists x.(Likes(x, sneakers) \rightarrow \neg Likes(x, boots))$

and tell whether each of the following sentences is either a logical consequence of the theory or not:

1. $\exists x.(\neg Likes(x, boots) \wedge \neg Likes(x, slipon))$.
2. $\forall x.(\neg Likes(x, sneakers) \rightarrow Likes(x, slipon))$.
3. $\forall x.(Likes(x, slipon) \vee Likes(x, sneakers))$.
4. $\forall x.(Likes(x, sneakers))$.
5. $\forall x.((Likes(x, slipon) \wedge \neg Likes(x, sneakers)) \rightarrow Likes(x, boots))$.

Please state your answers using a deductive mechanism of your choice or a semantic argument.

3 Planning

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

- One arm has a wrench and can tighten loose nuts, the other arm has a screwdriver and can tighten loose screws; some objects have just screws, some just nuts, some both of them; the robot can use only one arm at a time.
- 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 to be fixed or be empty.
- The robot must be in the room to fix an object in it.

In particular, formalize actions to move from one room to another, to tighten screws and nuts, as well as the predicates to characterize the state. Formalize a problem instance where there are four rooms and the robot is initially in room 1. There is an object with a loose nut in room 1, an object with a loose screw and a loose nut in room 2 and an object with a loose screw in room 3 and in room 4. The goal is to fix all the objects and return in room 1.