Artificial Intelligence for Robotics I
Final Test

December 22nd, 2022

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 are 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 name `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

Formalize the following sentences in propositional logic:

- Francesco or Giovanni are going to the restaurant.
- Chiara or Maria are going to the restaurant.
- If Francesco goes to the restaurant, then Chiara does not go.
- If Giovanni goes to the restaurant, then Maria does not go.

Show whether the sentence "Francesco is not going to the restaurant or Giovanni is not going to the restaurant" is a logical consequence of the sentences above, considered as a theory. State your answer as a proof using a deduction mechanism of your choice or a semantic argument. Truth-tables are not accepted as an answer. (**Note**: interpret "or" as inclusive disjunction.)

2 First Order Logic

Consider the following first order theory about pizza:

1. $\forall x.(Pizza(x) \rightarrow HasTomato(x))$
2. $\forall x.(Pizza(x) \rightarrow HasCheese(x))$
3. $\exists x.\neg Pizza(x).$

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

1. $\exists x.(\neg HasTomato(x) \wedge \neg HasCheese(x))$
2. $\forall x.(\neg HastTomato(x) \rightarrow \neg HasCheese(x))$
3. $\forall x.((HasTomato(x) \wedge HasCheese(x)) \rightarrow Pizza(x))$
4. $\forall x.(\neg Pizza(x) \vee (HasTomato(x) \wedge HasCheese(x)))$
5. $\forall x.((\neg HasTomato(x) \vee \neg HasCheese(x)) \rightarrow \neg Pizza(x))$

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

3 Planning

Consider a bar-tender robot which is supposed to fix drinks for customers. In order to be served, the drink must be poured into a glass from a dispenser; the glass should be fetched from a shelf and the dispenser should be unhooked from its stand. Pouring of the drink requires that the robot holds both the glass and the dispenser. Formalize actions to fetch glasses, hook/unhook the dispenser and serve drinks to customers. Consider a scenario where you have four glasses and one dispenser and you should serve four customers. Initially, all the glasses are empty and sitting on the shelf and customers are waiting for their drinks. Formalize the planning domain and a problem file corresponding to the scenario described. (**Note**: consider the dispenser to have an infinite supply of drink.)