Artificial Intelligence — Final Test

June 10th, 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".

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 **two text files** for the answer to section 3: one file containing the **domain definition** and the other containing the **problem definition**. Answers to section 3 in handwritten form will not be considered for grading. 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

Formalize the following sentences in propositional logic about four friends Carla, Diana, Mario and Bruno possibly having a party:

- If Bruno goes to the party, then Carla does not go.
- Either Bruno or Mario (or both) go to the party.
- If Mario goes to the party, then Diana goes as well.
- If Carla goes to the party, then Diana does not go.
- The party will not be held unless at least one female and one male friend are going.

According to your formalization, show whether the party will be held or not. State your answer as a proof using a deduction mechanism of your choice (resolution or DPLL). Truth-tables are not accepted as an answer.

2 Relational Logic

Consider a Herbrand universe with two constants, and the predicates P and Q. Given the following formulas:

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

show which are satisfied in all possible interpretations of P and Q and which one is not.

3 Planning

Use PDDL-STRIPS to formalize a logistic domain about locations, trucks and containers to be delivered, where containers are of two kind: 40 ft and 20 ft long. Consider the following constraints:

- A truck may haul either one 40ft container or two 20ft containers
- The locations are numbered from 1 to n and they are all connected one another, so trucks can move freely among locations.
- A location may contain containers or be empty.
- The truck must be at a location to load containers in it.
- The container must be unloaded in a location to be considered there.

In particular, formalize actions to move from one location to another and load/unload containers, as well as the predicates to characterize the state. Formalize a problem instance where there are five locations numbered from 1 to 5, two trucks, two 40 ft containers and four 20 ft containers. Initially, the large containers are at location 1, and there is one small container for each location numbered 1 to 4. All trucks are initially at location 4. The goal is to move all containers at location 5.