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1. Exercises for the Course „Description Logics“

Exercise 1:

Knowledge representation often involves information that is given only implicitly. Implicit information, in turn, often requires reasoning to make it explicit. To illustrate this, consider the following puzzle:

Donald and Daisy Duck took their nephews, age 4, 5, and 6, on an outing. Each boy wore a tee-shirt with a different design on it and of a different color. You are also given the following information:

(a) Huey is younger than the boy in the green tee-shirt;

(b) The 5-year-old wore the tee-shirt with the camel design;

(c) Dewey's tee-shirt was yellow;

(d) Louie's tee-short bore the giraffe design;

(e) The panda design was not featured on the white tee-shirt.

A solution to this puzzle consists in a complete description of the tee-shirts and ages of the three nephews.

(a) Solve the puzzle by hand. You will see that (human) reasoning is required to make all the implicit information explicit.

(b) Since this puzzle is given in plain English language, it can, in this form, not easily be processed by a computer program. Choose a logical formalism that is suitable for representing the puzzle so that it can be automatically solved by a computer program.

(c) Translate the five statements above into your formalism. Can a solution be computed from this translation? Do additional statements have to be added?

(d) Describe the logical reasoning problem that needs to be solved by a computer program in order to automatically solve the puzzle.

(e) Name a generic method for solving the identified logical reasoning problem(s).

Exercise 2:

When solving reasoning problems in knowledge representation, we are often interested in *decision problems*. These are problems that can be answered with "yes" and "no" such as "Does knowledge base K entail fact α?". When solving decision problems, we usually are interested in algorithms that are decision procedures, i.e., which are

- *sound*: whenever the algorithm stops answering "yes", this answer is correct.
- *complete*: whenever the correct answer is "yes", the algorithm stops after finite time and answers "yes";
- and *terminating*: the algorithm stops after finite time on every possible input.

According to this definition, can an algorithm be sound and complete, but not terminating? Can it be sound and terminating, but incomplete?

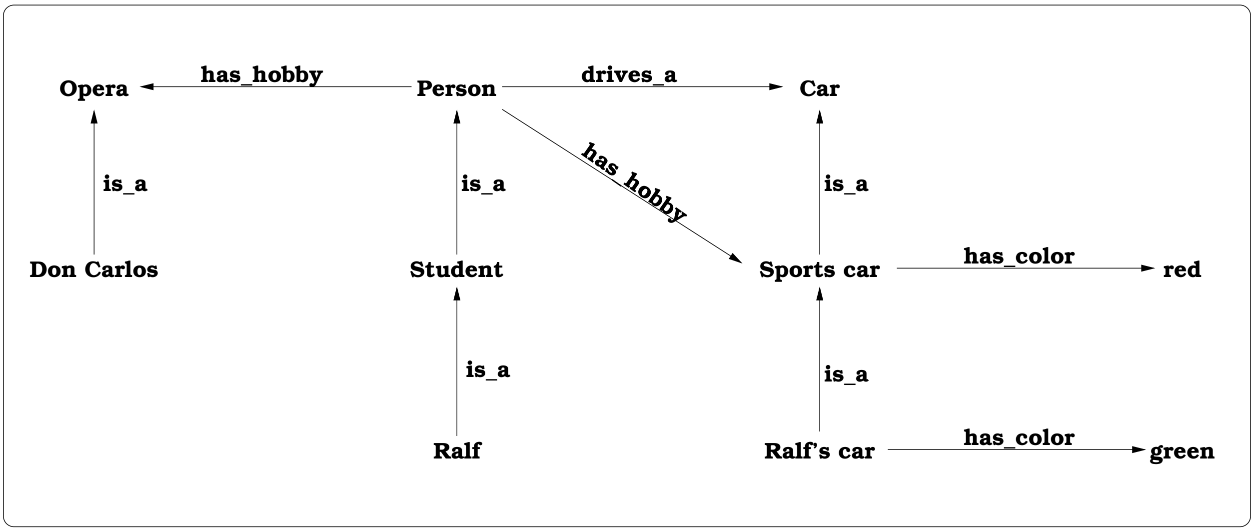
Assume that we use propositional logic for knowledge representation and that the reasoning problem we have to solve is the following: given a set Γ of formulas and a formula φ, decide whether $\Gamma \rightarrow \varphi$ is valid. Which of the following algorithms is sound/complete/terminating? What is the time consumption of the algorithms?

- Always return "yes".

- Always return “no”.
- Non-deterministically return either “yes” or “no”.
- Always enter an infinite loop, never returning.
- Using a Hilbert-style calculus, enumerate all valid formulas of propositional logic. If $\Gamma \rightarrow \varphi$ is among them, return “yes”. Otherwise, continue.
- Enumerate all truth assignments for the variables in Γ and φ. For each truth assignment, check whether it violates $\Gamma \rightarrow \varphi$. If a violating truth assignment is found, return “no”. Otherwise return “yes”.
- Convert $\Gamma \rightarrow \varphi$ into conjunctive normal form. If every clause contains at least two literals of the form x and $\neg x$, return “yes”. Otherwise, return “no”.

Exercise 3:

Consider the following semantic network:



(a) Which nodes are concepts, which objects?

(b) Describe some possible meanings of property edges.

(c) Which color has Ralf's car?

(d) What are the communalities between sports cars and operas?

Exercise 4:

Construct a semantic network that (partially) describes a university. Use concepts such as *professor*, *assistant*, and *student*, and relationships such as *teaches*, *is–employed–by*, *has-matrikelnumber*, *attends*, and *performs-exams.* Find additional concepts and relationships.