Description Logics

Winter Semester 2016

Exercise Sheet 1

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Exercise 1.1 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.

The athlete Herta Schinden has spent the entire weekend training for the Ironman triathlon. On Sunday evening, in her exhausted state, she only remembers the following.

(1) On Friday, she did not swim.

(2) She ran a shorter distance than she cycled.

(3) On Saturday, she covered a greater distance than on Sunday.

(4) She swam 2 km.

(5) She covered 60 km while it was cloudy and 20 km while it was sunny.

(6) It was not cloudy on Friday.

(7) On one of the days it was rainy.

Herta did not practice more than one discipline on one day and the weather did not change during one of the days. Can you help her with her lost memories?

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

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

Exercise 1.2 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 $\mathcal{K}$ entail fact α?". When solving decision problems, we are usually 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 algorithm stops answering "no", this answer is correct; and

- *terminating*: the algorithm stops after finite time on every possible input.

Assume that we use propositional logic for knowledge representation and that the reasoning problem we have to solve is the following: given a formula ϕ, decide whether ϕ is satisfiable. Which of the following algorithms is sound/complete/terminating? What is the time consumption of the algorithms?

(a) Always return "yes".

(b) Always return "no".

(c) Always enter an infinite loop, never returning.

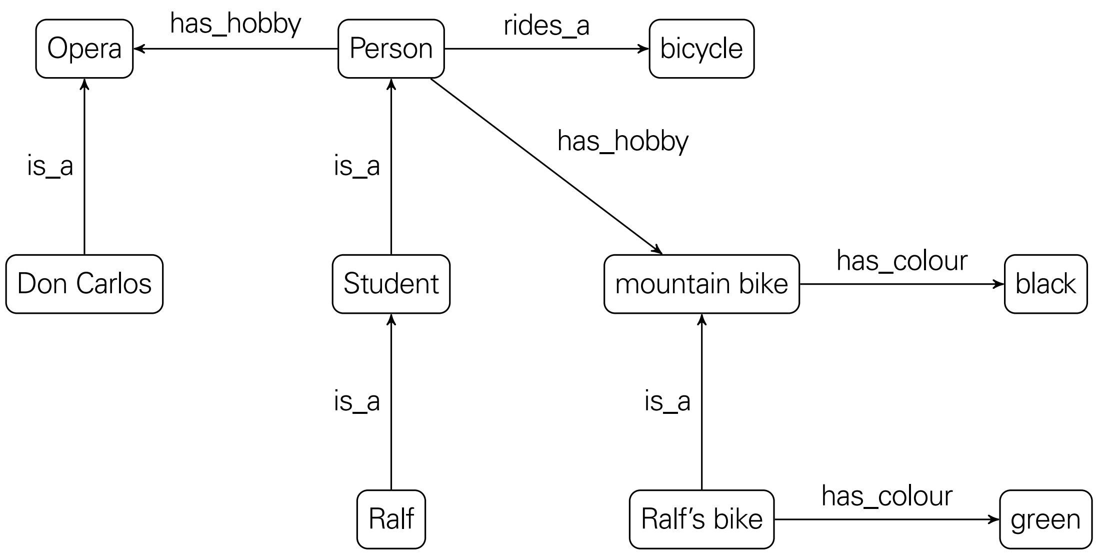
(d) Using a Hilbert-style calculus, enumerate all valid formulas of propositional logic. If $\neg\phi$ is among them, return "no". Otherwise, continue.

(e) Enumerate all truth assignments for the variables in ϕ. For each truth assignment, check whether it satisfies ϕ. If a satisfying truth assignment is found, return "yes". Otherwise return "no".

(f) Convert ϕ into disjunctive normal form. If every (conjunctive) clause contains two literals of the form x and $\neg x$, return "no". Otherwise, return "yes".

(g) Non-deterministically guess a truth assignment for ϕ. Check whether it satisfies ϕ, accept if it does and reject otherwise.

Exercise 1.3 Consider the following semantic network:



(a) Which nodes are concepts, which objects?

(b) Describe some possible meanings of property edges.

(c) What colour is Ralf's bike?

(d) What are the commonalities between mountain bikes and operas?

Exercise 1.4 Construct a

(a) semantic network and

(b) frame

that (partially) describes supermarkets. Use concepts such as `Supermarket`, `Shop`, `Food`, `Employee`, and property edges such as `sells` and `works-for`. Find additional concepts and relationships.