Knowledge Representation and Semantic Technologies

Exercises on Knowledge Representation

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Exercise 1

We want to formalize knowledge about the domain of students and professors.

In particular, we want to formalize the following statements:

Exercise 1 (contd.)

1. Every student is a person
2. Every professor is a person
3. Every student has an ID (matricola)
4. Every student attends at least one course
5. Every course is taught by a professor
6. Every student is not a professor
7. Every exam is constituted of a course, a student, a date and a grade

Exercise 1 (contd.)

1) Choose the most appropriate knowledge representation language for expressing the above knowledge among the following:

- ALC
- Datalog
- ASP
- OWL-DL
- DL-Lite$_R$
- EL
- RL
- RDFS

2) Express the above knowledge in the formalism chosen at the previous point.

Exercise 1 - Solution

1) The formalism chosen is ALC, because:
   - According to statements 3, 4, 5, we need to refer to «existential» individuals (and Datalog, ASP, RL and RDFS are not suited for this, so we can discard them)
   - According to statements 4,5, we need qualified existential restriction (DL-Lite$_R$ is not suited for this)
   - According to statement 6, we need to express disjointness between concepts (EL is not able to express this)

   So, only ALC and OWL-DL are able to express all the above statements. Therefore, we choose ALC (we do not need the extra abilities of OWL-DL).

Exercise 1 - Solution

2) We choose the following vocabulary (set of predicates and individuals):

Concepts: STUDENT, PERSON, PROFESSOR, COURSE, GRADE, DATE

Roles: hasID, attends, isTaughtBy

Moreover, we have ro reify the notion of exam at point 7 (that would be naturally encoded by a relation of arity 4) using a concept EXAM and four auxiliary roles examStudent, examCourse, examDate, examGrade

Exercise 1 - Solution

2) Here is the formalization of the statements in ALC:

$$\text{STUDENT} \sqsubseteq \text{PERSON}$$
$$\text{PROFESSOR} \sqsubseteq \text{PERSON}$$
$$\text{STUDENT} \sqsubseteq \exists \text{hasID}.\top$$
$$\text{STUDENT} \sqsubseteq \exists \text{attends}.\text{COURSE}$$
$$\text{COURSE} \sqsubseteq \exists \text{isTaughtBy}.\text{PROFESSOR}$$
$$\text{STUDENT} \sqsubseteq \neg\, \text{PROFESSOR}$$
$$\text{EXAM} \sqsubseteq \exists \text{examCourse}.\text{COURSE}$$
$$\text{EXAM} \sqsubseteq \exists \text{examStudent}.\text{STUDENT}$$
$$\text{EXAM} \sqsubseteq \exists \text{examGrade}.\text{GRADE}$$
$$\text{EXAM} \sqsubseteq \exists \text{examDate}.\text{DATE}$$

Exercise 1 - Comment

- Notice that statement 7 is problematic for ALC (and Description Logics in general), since DLs do not allow for expressing relations of arity greater than 2.
- However, the reification technique allows for representing (although unnaturally) these kinds of n-ary relations.
- Datalog and ASP allow for directly define a 4-ary exam relation, so, with respect to statement 7 alone, they should be preferred: however, they have more important limitations with respect to the other statements (in particular, both Datalog and ASP are not able to express statements 3,4,5; in addition, Datalog is not able to express statement 6)

Exercise 2

We want to formalize knowledge about the domain of students and professors.

In particular, we want to formalize the following statements:

Exercise 2 (contd.)

1. Every student is a person
2. Every professor is a person
3. Every student has an ID (matricola)
4. Every course is taught by a professor
5. Every student who attends a course is an active student
6. Every student is not a professor

Exercise 2 (contd.)

For each of the following description logics:

- DL-Lite$_R$
- EL
- RL

identify which of the above statements can be formalized, and write the corresponding axioms.